THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

· JANUARY · 1916 ·

Leading Features in this Issue

Dr. John A. Brashear's Presidential Address

During his term as president, Dr. Brashear traveled many thousands of miles (12,500 since September 1) for the purpose of meeting members. His lectures have delighted scores of audiences and his Presidential Address given at the Annual Meeting and published in this number of The Journal was listened to by the largest audience which ever attended the opening session of one of our Annual Meetings.

Annual Meeting Papers

Significant of the papers presented at the Annual Meeting is the fact that their authors are from every section of the country and they write with authority on their special subjects. The authors of the papers published in this issue and their topics are:

F. W. Dean, mill engineer and architect, Boston. Member of the Society since 1883. Gives chief causes of boiler explosions and methods of preventing.

Paul A. Bancel, associated with the Geo. H. Gibson Co., in New York City. Describes his elaborate experiments in water-tube boiler circulation.

Robert Cramer, engineer and designer, Motor Engineering Co., Chicago. Advocates higher steam pressures.

Geo. H. Gibson, head of Geo. H. Gibson Co., consulting engineers, New York City. With Paul A. Bancel, discusses high vacuum surface condenser performance.

A. L. Menzin, efficiency engineer, Philadelphia. Develops and applies formulae for calculating chimneys on gas basis.

Mark A. Replogle, consulting engineer, Akron, Ohio. Describes a new turbine discharge accelerator at Henry Ford farms.

Boiler Code Interpretations

The Boiler Code is one of the greatest and most far-reaching of any report ever drafted by a committee of a society. The Code was issued over the signatures of twenty-four experts representing every phase of steam boiler practice, and this body has been continued as a committee to interpret the Code when occasion requires. Forty-three rulings, and interpretations, of the utmost importance to engineers, are published in this number of The Journal.

THE SPRING MEETING, APRIL 11-14

IMPORTANT NOTICE. In view of the early date of the Spring Meeting it is necessary for papers to be in the hands of the Secretary by February 10 to insure their consideration for that meeting. On account of the time required for all the members of the Committee on Meetings to read the papers submitted, and because of the insistence of the membership that the accepted papers be printed and distributed well in advance of the meeting, any papers received after the date mentioned are liable to be held over for a later meeting.

Are You Going to New Orleans

The Spring Meeting will be held in New Orleans, beginning Tuesday, April 11 and ending Friday, April 14, 1916. This date is six weeks earlier than usual and it is urged that all who expect to attend or who will offer papers should make early arrangements.

The following schedules for transportation to New Orleans are offered in order that the membership may have an opportunity to express a preference. If 100 or more will go in one party a special train may be secured and a schedule arranged to suit the party, stopping at Mammoth Cave, or other points of interest. Transportation may be either by train or boat; or one way by train and one way by boat. [redacted]

ROUTE NO. 1, VIA CINCINNATI AND BIRMINGHAM

Members from the East and West would join forces at Cincinnati, Sunday, April 9

	(a) Via L. & N.	(b) Via Q. & C.	
Leave Cincinnati	6.15 p.m.	8.00 p.m.	Sunday
Arrive Birmingham	8.52 a.m.	10.20 a.m.	Monday
Leave Birmingham	3.55 p.m.	10.35 p.m.	Monday
Arrive New Orleans	7.15 a.m.	9.40 a.m.	Tuesday

(c) A third schedule would be to leave Cincinnati at 8.00 a.m. on Sunday, which would give one full day of 24 hours in Birmingham.

ROUTE NO. 2, VIA WASHINGTON AND ATLANTA

A stop of 24 hours can be arranged at Atlanta by starting on Saturday, as per the following schedule:

Leave New York (via Penn)	4.35 p.m.	Saturday
Arrive Washington	10.25 p.m.	
Leave Washington (via Southern)	10.45 p.m.	
Arrive Atlanta	5.00 p.m.	Sunday
Leave Atlanta	5.00 p.m.	Monday
Arrive New Orleans	7.50 a.m.	Tuesday

ROUTE NO. 3, BY BOAT

Five days are required for the trip between New York and New Orleans.

Leave New York (via So. Pac. S. S. Line)	Wednesday, April 5
Arrive New Orleans	Monday
Returning,	
Leave New Orleans	Saturday
Arrive New York	Thursday

RATES

Round trip fare $75.00

This includes steamship both ways or railroad going and steamship returning or vice versa, and includes meals and berth on steamer. This provides also for those who start from an inland city, as Cincinnati, going by rail to New Orleans, returning by steamer to New York and thence by rail to Cincinnati. For parties of 10 or more going on one ticket by rail, and returning by steamer the round trip is $70.19.

Round trip by rail, New York to New Orleans, $56.30.

Pullman Fares: New York to New Orleans, $8.00 lower berth; $6.40 upper berth.

RETURN BLANK

Will members kindly indicate their choice of routes on the attached blank and return it as early as possible to assist in making definite arrangements.

..............................1916

The American Society of Mechanical Engineers,
29 West 39th Street, New York N. Y.

I expect to attend the Spring Meeting of the Society to be held in New Orleans April 11–14, and my choice of routes is as follows:

First Choice—Route No.............Returning by {Rail / Boat}

Second Choice—Route No...........Returning by {Rail / Boat}

Signed..

Address...

NEW MEMBERS

HEREAFTER there will be published each month a summary giving data regarding the current ballot for new members, as to the type of positions held, the average age of those being considered by the Council for each grade, and the number who are college graduates.

Beginning with the February issue a list will be published of those new members who qualify each month, so that hereafter it will not be necessary for the members to wait until the new Year Book is published for information regarding those who have been added to the Society's rolls during the year.

This additional information will undoubtedly be of particular interest to the membership and testify to the excellent character and high standing of those joining the Society under the present strict requirements.

The following tabulation shows the high standing of the applicants recommended to the Council by the Membership Committee for election in December and January:

AVERAGE AGE OF APPLICANTS

	December	January
Members	41 years	38 years
Associates	38 "	49 "
Associate-Members	33 "	31 "
Junior	24 "	23 "

POSITIONS HELD BY APPLICANTS

	December	January
Presidents	2	3
Vice Presidents and Asst. Vice Presidents	2	5
Secretaries and Treasurers	2	2
Managers and Assistant Managers	5	7
Consulting Engineers	4	5
Mechanical Engineers	41	37
Engineering Specialists	8	16
Designers and Draftsmen	10	6
Investigators and Statisticians	3	4
Superintendents and Asst. Superintendents	14	11
Foremen and Assistant Foremen	2	4
Inspectors	4	4
Instructors	4	4
Technical Graduates and Miscellaneous	11	8
	112	116

New applications received in December, 1915, are posted on page 65.

Total Membership of the Society, January 3, 1916	6931
New Members added in the year 1915	926
Members lost in the year 1915	137
Net gain in members during 1915	789

COMING MEETINGS OF THE SOCIETY

January 5, *Buffalo, N. Y.* Subject: The History of Iron, by Dr. J. A. Mathews, Mem. Am. Soc. M. E., of the Halcomb Steel Company.

January 11, *New York, N. Y.* Subject: Standardization of Power Plant Operating Costs, by Walter N. Polakov, Mem. Am. Soc. M. E.

January 19, *St. Louis, Mo.* Subject: Certain Phases of Scientific Management in Machine Shops, by Carl G. Barth. This will be a joint meeting under the auspices of The American Society of Mechanical Engineers.

January 20, *St. Paul, Minn.* Annual Banquet and Dance.

January 20, *Buffalo, N. Y.* Subject: Electric Railway Signalling, by Henry M. Sperry, of the General Electric Railway Co.

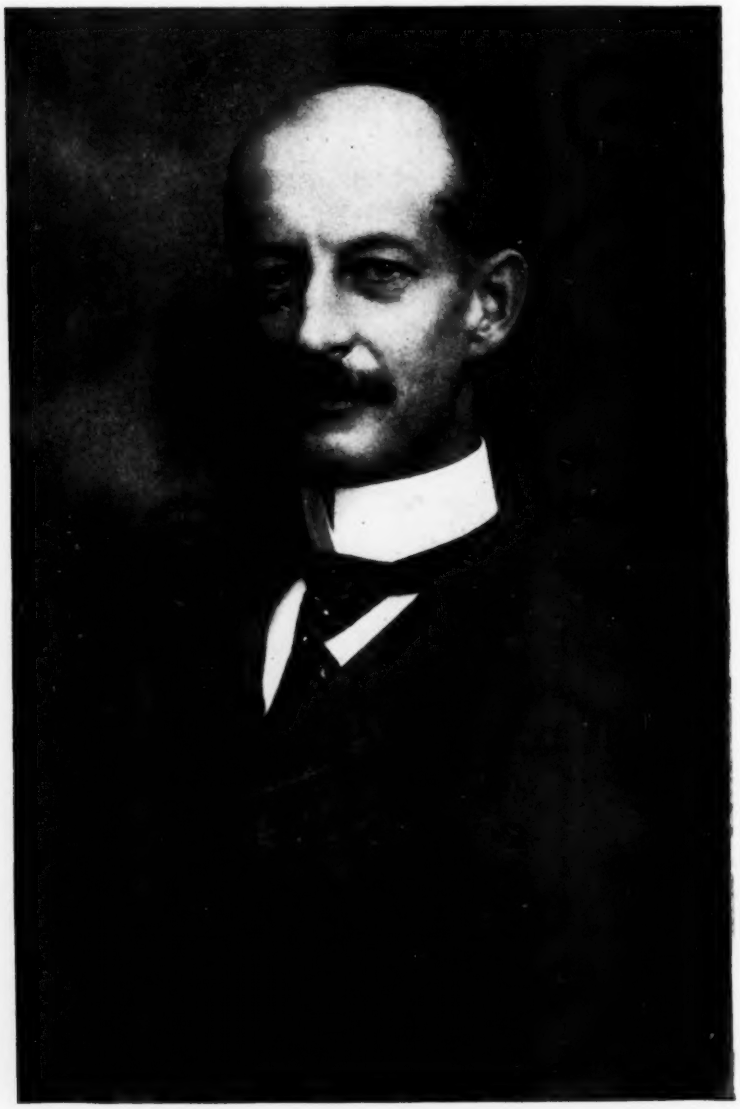
January 26, *Providence, R. I.* Subject: The Work of Underwriters' Laboratories in Fire Prevention, by Franklin H. Wentworth, Secretary of the National Fire Protection Association of Boston. The lecture which will be illustrated by motion pictures, will be held in the Engineering Building of Brown University at 8 p. m.

February, Worcester, Mass. The address will be given by Dr. Hollis. The date and subject of the meeting will be announced later.

February 2, *Buffalo, N. Y.* Subject: Public Service, by Morris L. Cooke, Mem. Am. Soc. M. E., Director of Public Works, in Philadelphia.

THE SPRING MEETING

April 11–14, *New Orleans, La.* Spring Meeting of The American Society of Mechanical Engineers.



DAVID SCHENCK JACOBUS
PRESIDENT 1916
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE JOURNAL OF
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Volume 38 January 1916 Number 1

THE ANNUAL MEETING

THE 36th Annual Meeting held in New York, December 7-10, had the largest registration of any in the history of the Society. Of the thirty papers and reports presented, fourteen were contributed by committees and seven by Local Sections, indicating the wide participation of the membership. At the opening session, Dr. John A. Brashear's audience filled the large auditorium of the Engineering Societies Building, and this interest was sustained throughout. Enthusiastic conferences were held by representatives from the Fourteen Local Sections and plans were laid for greater development of the Society. Abstracts of a portion of the papers and an account of the meeting appear in this issue.

SCIENCE IN ITS RELATION TO ENGINEERING

Presidential Address

BY DR. JOHN A. BRASHEAR, PITTSBURGH, PA.

The early history of engineering in at least three of its phases,—namely, civil, mining and mechanical,—has much of interest to the technical student of to-day, and we of the twentieth century would be false to our convictions did we not give our mead of praise to the pioneers who have left in evidence some of the monuments of their labors which stand almost unimpaired after the ravages of many centuries.

Some of the members of our Society had the pleasure of visiting the Panama-Pacific Exposition and participating in the celebration of the completion of the Panama Canal. It was a great event, but we should not forget that many centuries ago the possibility of building a canal to connect the Mediterranean and the Red Sea was seriously discussed by the engineers of that day. The project was considered impractical because it was suggested that there was a difference of level of over thirty-two feet between the two bodies of water, although the great mathematician La Place insisted that this could not be possible, since by the law of gravity there could be no difference in the mean level of large bodies of water on the earth.

Greek historians tell us that it was the fear of flooding Egypt with the waters of the Red Sea which prevented Darius from undertaking the canal project, yet this canal was successfully constructed centuries after the time of Darius.

The pyramid builders were certainly engineers of no mean type. The handling of those massive stones, many of them weighing as much as thirty tons, their transportation and the placing of them in position, were problems that would concern the engineers of to-day. As a matter of minor interest, it seems almost certain that hollow diamond drills were used at this early period.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies may be obtained; price 5 cents to members; 10 cents to non-members.

I had the pleasure of a personal acquaintance with the astronomer Piazzi Smyth, who made a critical study of one of the great pyramids of Egypt; and while I cannot agree with his dictum that the base of the pyramid is the divine standard of measurement, I could not help being deeply impressed with his views of the engineering problems that were mastered in the erection of these wonderful structures.

I cannot refrain from mentioning a piece of engineering work of later date, namely the building of that splendid highway, the Via Appia. While the time element in its construction would be inexcusable in modern road building, and although it was probably never subjected to a tithe of the use and abuse of modern highways, the fact that it was in perfect repair nearly six hundred years after it was finished speaks volumes for the character of the engineering work done upon it. Three bridges and a small portion of the roadway still remain after the lapse of twenty-two centuries.

Roman engineers built more than forty thousand miles of such roadways through and out from the Roman provinces, and it is recorded that the water supply of the empire at the beginning of the Christian era would suffice for a population of seven million people. The aqueducts of Rome are considered among her grandest engineering works.

It would be impossible and, indeed, out of place to enumerate the achievements of the past in the many lines of civil, mining and mechanical engineering. My purpose in mentioning some of the work of our ancient brethren is to note the facts that what they constructed was largely upon an empirical basis; and that, nevertheless, their factors of safety were amply large. In many of the blunders of later date which, for want of a better name, may be styled scientific empiricism, "safety first" has unfortunately not always been the slogan.

In an admirable address given before the British Association of Science some forty years ago, Sir John Hawkshaw tells us that when knowledge in its higher branches was confined to the few, those who possessed it were called upon to perform various services for the community to which they belonged, and that mathematicians, astronomers, painters, sculptors and priests performed duties which now pertain to the professions of the architect and engineer.

Thus while it is true that the methods which were followed up to, let us say for safety three centuries ago, were largely empirical, perhaps we can see in the work of the painters and sculptors the why of the beautiful types of architecture from which the architects of to-day are unwilling to depart.

I dare not undertake to mention in extenso the various steps in the evolution of scientific research and its correlation with engineering problems. I bow my head in reverence to the great geometers and mathematicians of the past, men whose names are household words to the engineer of to-day, Pythagoras, Euclid, Pascal, Gregory, Ptolemy, Huygens, Descartes, Newton, Hamilton, La Place, Napier. Great have been their contributions to human knowledge, giving us the key that has enabled other master minds to solve some of the mysteries of God's illimitable universe.

But the science of mathematics has many handmaidens for probing into the hitherto unsolved problems of this old round world. Astronomy, physics, chemistry, and kindred sciences, have and ever will have their place in the world's great workshop, and ever will hold a place of honor in the great field of engineering.

There is not a single problem in modern engineering that can not be more readily solved by a knowledge of facts developed by scientific study and research, and no man knows this better than the successful engineer of to-day.

Dr. Maclaurin tells us a story of Matthew Arnold, the apostle of Sweetness and Light, in which he is made to say, that when a candle burns the oxygen and nitrogen of the air combine with the carbon in the candle to form carbonic acid gas, *but who cares?* The story is told because it suggests an attitude to science that is far from rare, even amongst people of intelligence to-day. He recalls the poetic query of Keats when he writes of the rainbow: "Do not all charms fly at the mere touch of philosophy? There was an awful rainbow once in heaven, we know her woof and texture. She is given in the dull catalogue of common things."

"The complaint seems to be that science with its analysis robs us of the pleasing sense of awe and mystery, but if you dig deep, you will find enough mystery left to satisfy the keenest yearner after half lights and the obscure. At best, science replaces one mystery only by another of grander order."

Now, leaning for a moment from the purely utilitarian side of science, to the esthetic, there comes a joy to the lover of the beautiful that cannot be expressed in words, for he sees in the color of an American Beauty rose the same light waves that tint yonder red star, whose light waves, coming to him at the rate of 180,000 miles per second, left it a thousand years ago; he listens to the varying bell tone of the swiftly moving locomotive and translates it into the motion of stellar worlds, whose distances have never before been measured by the most refined modern instruments.

Does the photographic picture of your favorite landscape lose any of its beauty when you are told that during an exposure in your camera of only one-tenth of a second, from forty to eighty millions of millions of light waves have hammered upon your negatives tending to shatter them to pieces or change their molecular arrangement?

Maclaurin gives a charming illustration to help us better understand what it means when a ray of violet light impinges on our photographic plate for one-tenth of a second. "Imagine you are watching a log floating near the seashore, and that it strikes against a pier as it rises and falls with the waves, say, once in six seconds. In order to correspond to the number of light waves in one-tenth of a second, the log would have to beat against the pier for more than two million years."

But enough for the present of the esthetic side of science, though it has beauties in its every phase, whether it be in the flower or in the rainbow—whether it be in the structure of glass from which the prism is made, or the story it tells of yonder far-off stellar universe. But can we connect this science beautiful with our engineering problems? Why not?

It is a long way from the sun dial of Ahaz to the Riefler clock; a long way from the Pyramid of Cheops to the stately steel structure of our great cities; a long way from the cubit span and hand-breadth to the standard metre whose value is determined in light waves; a long way from the ox-cart with its wheels cut from the end of a log to the steam and electric locomotive; a long way from the log bridge across the narrow streams to the magnificent steel and concrete spans that now cross our widest rivers; a long way from the tiny Egyptian cedar boat, built without iron, steel or copper, to the majestic steel steamships that daily cross the ocean; a long way from the smoke balloon of Montgolfier to the dirigible, or the biplane that soars like a bird through our skies; yes, and all along the pathway of the evolution of these and other inventions of man are unwritten histories which, if told, would be filled with romance and ofttimes with tragedies,—aye, with the sacrifice of the lives of many of the world's noblest pioneers who have contributed to the treasures of our vast storehouse of knowledge.

We can look over time's vistas and learn that to Aristotle we owe the beginning of exact science and research, fostered by his love of experimentation. Indeed, Hale records that, although his theory of the fixity of the earth was based upon false premises, he left his impress so deeply upon the islands and borderlands of the Mediterranean that, after he had passed from his labors, there was a gradual separation of the investigations in natural science from the speculations of the philosophers, and that true scientific research, in the modern sense, developed with remarkable rapidity.

I have always had the conviction that we give too little thought to the pioneers in any line of research, and I have often bowed my head in reverence to those who, with the most limited means and equipment, by patient, persistent plodding, wrested the secrets of nature from their entanglement.

There has often arisen in my own mind, and no doubt in yours, the question: Where shall we draw the line between pure and applied science? For myself, I have been unable to find aught but a hazy line of demarkation, and in my long life I have known but few men who, in their mathematical researches and calculations, could see nothing in the way of an entity before them; indeed, but one great mathematician has told me it was his regret that he could see no picture of a beautiful comet while he was calculating its orbit, nor could he form a visual image of the planetary world whose perturbations he was computing by his wonderful mathematical formulae.

Nor can I see how pure science and its allies can be relegated to opposite poles. For a time apparently they may point in opposite directions, but at each end there lies some great truth. One may be a hitherto undiscovered law of nature and the other, let us say, something of an utilitarian character, that, material as we may call it, will cause these opposite poles to curve toward each other and add to the sum of human knowledge, human betterment and happiness.

Let me illustrate. When the velocity of the propagation of light waves was determined by scientific reasoning and experimentation of the most refined nature, and successively by

Roemer, Bradley, Fizeau, Foucault, and our own Newcomb and Michelson, the process of solving the problem remained for a long time in the domain of the exact sciences as a masterpiece of the human mind.

But who of us dreamed to what an utilitarian purpose these light waves would be made subservient? The genius of a Michelson carried them into the workshop, thence to the International Bureau of Weights and Measures at Sèvres, and gave us a value for the International metre in terms of light waves that will remain absolutely unalterable as long as this old world moves in the lumeniferous ether of the universe. And so we now know that our standard metre, measured in terms of the red radiations or wave length of cadmium, equals 1,553,163.5; for the green radiation, equals 1,966,249.7; and for the blue radiation, 2,083,372.1, in air at 15 deg. cent. and normal atmospheric pressure.

Michelson tells us that the absolute accuracy of these measures is one part in two millions, the relative accuracy, one part in twenty millions.

Getting nearer the utilitarian service of the scientific study of light waves, let me say that Dr. Anderson of the Johns Hopkins University has utilized them in making screws of hitherto unheard-of accuracy. Let me quote from a letter received from Dr. Anderson before writting this address:

In reply to yours of the 4th, I will say that from measurements made by using a Fabry and Perot Interferometer, the screws we have made for ruling purposes have the following accuracy:

1. The maximum variation in pitch along the screw did not exceed *one-ten millionth of an inch*. (By pitch, I mean the average value of the pitch as given by a well-fitting nut three or four inches long.)

2. The axis of the screw had a radius of curvature longer than *250 miles*.

3. The axis of each pivot or bearing coincided with the axis of the screw to within one two-hundred thousandth of an inch.

These are three important quantities as far as the screw itself is concerned.

When the screw is mounted ready for use, it is also important that it be prevented from moving endwise or longitudinally when it is rotated. Our mounting, using the flat ruby against a spherical steel surface, makes it possible to reduce this motion to something less than one millionth of an inch. Errors of the magnitude given above can be easily detected with the interferometer.

Our fellow member, George M. Bond, has given us a most valuable compendium of the development of measures of precision in his work on "Standards of Length," from which I quote as most interesting, and bearing forcibly upon this part of our topic:

It is worthy of note that a remedy for the evil complained of by master car builders, that nuts made by some firms or at some shops would not screw on bolts made by others, at first baffled the ability of the most prominent manufacturers of tools of precision in the country, and that to provide an adequate remedy it was necessary to secure the assistance of the highest scientific ability in the country, which was supplied through the coöperation of the Professor of Astronomy of the oldest and most noted institution of learning in the land. The man of science turned his attention from the planets and the measurement of distances counted by millions of miles, to listen to the imprecation, perhaps, of the humble car-repairer lying on his back and swearing because a ⅝ nut—"a leetle small"—will not screw on a bolt—"a trifle large." It is a striking example of the assistance which science can give in conducting the "practical" affairs of life.

Here I wish to pay a tribute to our American engineers who have developed instruments for mechanical measurements to such a high state of precision, which in their turn have been such valuable factors in the development of interchangeable machinery. I need not dilate upon these interesting topics, but I cannot refrain from offering a word of praise to these earnest men whose ideals have been of the highest—by their work we know them.

I am sure all will be interested in what may be called a paradoxical statement—but is not—namely, that through the marvelous precision atttained by Rowland, and later by Anderson, in the construction of accurate screws, we have made what must be considered an utilitarian use of pure scientific research. This utilitarian use of science has reacted, as it were, and enabled the scientific mechanician to produce an optical device that rivals, if it does not surpass, the telescope in unraveling some of the most profound secrets of the universe.

I hold in my hand (shows a diffraction grating) a little instrument called a diffraction grating. On the plane surface of this polished plate, made accurate to one-tenth of a light wave, or within one tenth of one forty-five thousandths of an inch, are ruled more than 45,000 lines between which there is no greater error than one two-millionths of an inch. With this delicate piece of apparatus, made possible *first* by rigorous scientific research, *second* by the skill of the artisan, *third* by a knowledge of and vigorous care to avoid temperature changes and *fourth* by the accuracy of the mechanism which includes the accurate screw mentioned above, the astrophysicist has been able to tell us the composition, temperature and distance of the stars. It is also possible for the physicist, the chemist, to tell us the purity of the material he is called to investigate; indeed, it makes itself subservient to many phases of engineering in the domain of metallurgy. And the end is not yet. Where can we then draw a sharp line of demarkation between pure science, and its relation to any and every form of engineering?

Twenty-seven years ago I was the guest of my friend Sir James Dewar, the worthy successor of Tyndall in the Royal Institution of Great Britain. Taking a tiny piece of apparatus out of the "holy of holies," and placing it in my hands, he told me it was the father and mother of all the dynamos and electric lighting systems of that day. *It was the first little dynamo made by Michael Faraday.* What has come to us since that visit, in the domain of the electric development through scientific investigation and mechanical devices!

Thirty-seven years ago I listened to the first faint telephone message over a few miles of wire. On the 24th of January last, through the courtesy of our friend Mr. Carty, chief engineer of the American Bell Telephone Company, and Dr. Bell, I listened to the voices of Watson and Moore across the continent. When this Society was the guest of the officials of the Panama-Pacific Exposition, I was taken to the private office of the telephone company in the Exposition building, where, through the courtesy of our friend Engineer Carty, I not only listened to cheerful words spoken in this city, but heard the sound of breakers as they dashed upon the shore of the Atlantic.

When we made the first little spectroscope to determine the moment when the last ounce of carbon had disappeared from the Bessemer converter, little did I dream that through science, aided by a delicately accurate instrument, devised by my good friend, Dr. George Ellery Hale, and made at "the little workshop on the hill," we would be able to plunge it, as it were, into a storm on the sun and photograph the burning hydrogen or any other element in that maelstrom of fire, the temperature of which this earth knows no correlative.

Here let me add some altruistic words of our good friend Dr. Pritchett:

> The last fifty years have seen a greater betterment of the theoretical basis of physical science than ever before in the history of the world. This development has been marked by a notable stimulation of scientific research, a differentiation of scientific effort, and the creation thereby of a great number of special sciences or departments of science. The possession of a secured theoretical basis and the intellectual quickening which has followed it have resulted in the application of science to the arts and to the industries in such measure as the world has never before known. These applications have to do with the comfort, health, pleasure and happiness of the human race, and affect vitally all the conditions of modern life.

As members of this association we may well be proud of our Bureau of Standards, organized and brought to its present high state of efficiency by our fellow member, Dr. Stratton, and his splendid corps of associates. This scientific department of our Government, concerning as it does almost every phase of scientific research, valuable to the engineer of every calling, has made a record even greater than the Institute at Charlottenberg and the famous Bureau International des Poids et Mesures at Sèvres, though they have done splendid work for a half century or more. I am certain that every member of this association would place a very high value upon the scientific studies of our Bureau of Standards did they know how closely they are related to their profession.

Other scientific departments of the Government, such as the United States Coast and Geodetic Survey and the Smithsonian Institution, have in the past and are continually contributing to the sum of knowledge that is of value to the engineering profession in some of its many phases. Nor can we pass over the splendid research work of the Carnegie Institution at Washington without a tribute of praise for its great accomplishments in the past and its present activities in the domain of scientific investigation of the highest value to engineering and its correlated interests.

It would be a serious oversight in this paper did I not call attention to what I may name humanitarian engineering investigation, based upon a phase of scientific research we would probably consider far removed from engineering problems per se. I refer to the magnificent, and now classic applied scientific medical research of my dear departed friend, General Sternberg, and General Gorgas, who made possible the carrying out of one of the greatest engineering projects the world has ever known. All honor to these good men!

But I must stop. The great, the illimitable field of truth opens up before us; aye, I love to liken it to the "Widow's Cruse"; take from it as you will, it will never be emptied of its priceless treasures.

And is there not a splendid field opened up to us in the endowment of engineering research, now made possible by the gift of one of our honored presidents? I have said little of specific lines of investigation in relation to engineering, having given only a few instances to show their close and intimate relationship, and it needs no further words of mine to verify the aphorism that "the field is ripe for the harvest."

In closing may I quote from the recent publication by Dr. Hale, entitled: "National Academies and the Progress of Research:"

> But the average man of business is much better able to appreciate the value of research directly applied to the improvement of manufactures than to comprehend the more fundamental importance of pure science. We must show how the investigations of Faraday, pursued for the pure love of truth and apparently of no commercial value, nevertheless, laid the foundations of electrical engineering. If we can disseminate such knowledge, which is capable of the easiest demonstration and the most striking illustration, we can multiply the friends of pure science and secure new and larger endowments for physics, chemistry and other fundamental subjects.

Dr. Hale's valuable brochure can be found in our library and is worthy of our careful study. Here we have a striking note of the value of scientific research, and a touch of its utilitarian value, but after all is said, a knowledge of the true and beautiful, whatever its bearing may be, stands for human progress, human betterment and human happiness.

May I also quote from a letter received from the same gentleman by the donor of our research fund:

> I am delighted that you, with a thorough knowledge of the situation, agree with me in thinking that the time has come for much closer coöperation between engineers and men of science. Previously I have not been able to judge the matter from the standpoint of the engineer, but it was plain to me that the separation between pure and applied science, which seems to have been increasing, must be harmful to both. The man of science is liable to underestimate the importance of practical applications of his subject, while the engineer is in danger of forgetting that if research were conducted only in the hope of securing profitable ends, most, if not all, of the great discoveries which lie at the very foundation of both pure and applied science, would never be made.
>
> Thus every effort should be made to encourage and develop research in both pure and applied science, for neither can be neglected without loss to the other. The dual nature of this problem is thus perfectly evident. Sound strategy requires that the attack be made simultaneously from both sides, since in this way all difficulties can be overcome far more quickly than by two successive attempts.
>
> These difficulties are likely to be due mainly to the conservative tendencies of both engineers and men of science. By establishing your research fund you have provided means to obviate the chief practical hindrances on the engineering side, where the way has always been paved by the successful research of the General Electric Company and various other large corporations. It now remains to accomplish an equally important advance on the side of pure science.

Dr. Hale is very anxious that there shall be a closer relationship with the National Academy of Sciences, and I think I can say without hesitation that it will be a wise move upon the part of all engineering societies to appoint a special committee to act in conjunction with the Academy toward this most desirable affiliation.

In my desire to be brief, I have refrained from going into the many, very many fields where pure science may take the hand of fellowship of the engineer, and now that there has come to us a grand opportunity, fostered by the splendid research fund placed in our keeping, may we look forward with hope to the day when science and engineering will join hands for the betterment of our loved profession.

"To-day we are learning but single notes, to-morrow we will blend them into chords, the hour will chime when all humanity shall know the law of harmony—when every note in every chord shall find its part in the sublime oratorio of the universal life."

DESIGN OF FIRE TUBE BOILERS AND STEAM DRUMS

BY F. W. DEAN, BOSTON, MASS.

Member of the Society

As is now generally understood, the most prolific cause of explosions of fire tube boilers has been lap longitudinal joints, and the use of butt joints with inside and outside covering plates has, so far, prevented such explosions. The lap joint makes the boiler non-circular at and in the vicinity of the joint; and when pressure is applied the plate, in its effort to become circular, bends somewhat, and on the reduction or removal of pressure, it tends to return to its original form. The frequent repetition of these actions causes the plate to crack and finally to become too weak to stand the stress caused by the working pressure. Boiler plates with lap joints have often cracked entirely through for a greater or less distance, and the escape of steam has given warning in time to prevent an explosion.

THE DESIGN OF BUTT JOINTS

The joint which has a narrow butt strap on one side of the shell and a wide one on the other is one-sided, and its center

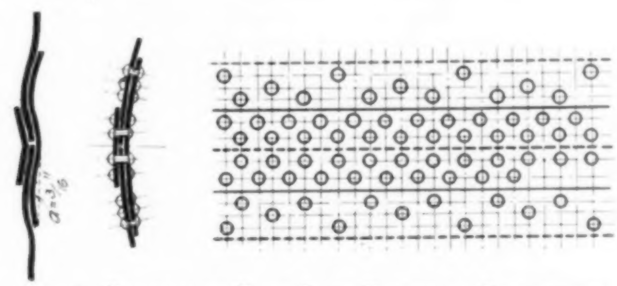

FIG. 1 BENDING OF BUTT JOINT TESTED TO DESTRUCTION

of resistance does not coincide with the center of pull of the shell plate. That part of the wide strap which extends beyond the narrow one is riveted to the shell, and this outer part of the joint is a lap joint with its peculiar defects. The rivets in this part of the joint are overhung and in service tend to tip over and bend the joint. This is only another way of stating that the joint is a non-central resisting device, and must cause the plate in and near the joint to bend when the boiler is subjected to pressure. Fig. 1 shows how this bending occurs when such a joint is tested to destruction, this being the result of several actual tests.

In order to prevent a joint from bending, a butt joint with straps of the same width and with all rivets in double shear should be used, as is always done in Europe. The center of resistance of such a joint coincides with the center of pull in the shell. The joint when tested to destruction remains straight, without bending; and by its use the only probable cause of boiler explosions so far as the design of the joint is concerned is eliminated. There are various designs of such joints ranging from the simplest joint with double covering plates of equal widths, to the joints shown in Figs. 2 and 3.

Fig. 2 illustrates a design which is used largely in marine practice in this country and abroad and which has a theoretical efficiency of about 85 per cent. Fig. 3 shows a more efficient joint, having a theoretical efficiency of from 92 to 94 per cent. In the joint in Fig. 3 the outer strap is cut away between the rivets in order that it may stand caulking; the high efficiency is secured by the wide pitch of the outer rows of rivets.

BRACES

Boiler head braces of the crow foot or similar types are usually designed so thin that they bend in service where the foot joins the rod, and are likely to break finally at this point. This detail should be made stiffer than is commonly done.

Through rods above the tubes of horizontal return tubular boilers should be supported so that they cannot vibrate, and the supports should be stiff enough to prevent movement in any direction, instead of merely supporting the weight. If any braces are used below the tubes, through or head-to-head braces, rather than braces riveted to the shell, should be employed. Such braces should not, however, pass through the back head on account of the nuts being in contact with the fire. The rods should be secured to angles riveted to the back head but separated from it 2 to 4 in. by ferrules around the rivets, in order to permit the removal of dirt between the angles and the head.

Although not related to safety, it is best not to have the rods above the tubes pass through the back head, because the nuts interfere with an efficient method of covering the back con-

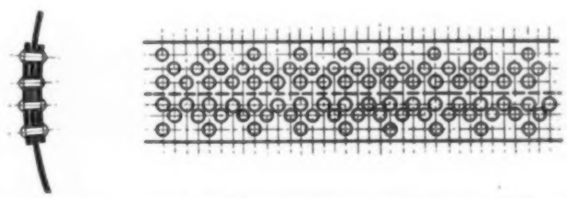

FIG. 2 BUTT JOINT USED IN MARINE PRACTICE. EFFICIENCY ABOUT 85 PER CENT

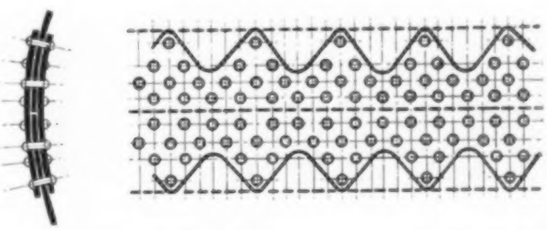

FIG. 3 BUTT JOINT WITH EFFICIENCY OF 92 TO 94 PER CENT

nection with fire brick. There are various ways in which nuts can be avoided, and Fig. 4 shows methods of staying both above and below the tubes. In the former case diagonal braces are used for staying the upper parts of the tube plates in order to give more room for inspection, and the heads are stiffened by riveting on thick plates. In England plate gusset stays are preferred to through rods or diagonal stays, but in this country they are seldom used. There is, however, no reason to doubt their efficiency, although any head stay attached to the shell tends to bend the latter and throw it out of equilibrium. Nevertheless I have never heard of a rupture coming from this cause.

RIVET HOLES AND RIVETING

Riveting is now generally done by hydraulic machines, which have shown themselves superior to any other kind. In consequence of the slow movement of a hydraulic plunger the rivets have time to enlarge and fill the holes; and from the solidity of action and steady holding power of the machine the plates are firmly pressed together, with the result that joints riveted by this type of machine are tighter than those made by any other.

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It is the common practice in this country to punch the holes of boilers $\frac{1}{8}$ in. or $\frac{1}{4}$ in. small and then to drill them to size with all plates and covering plates in place. This is a great advance in practice over punching to size, but it is not satisfying to the imagination and it may be one reason why plates exposed to the hottest gases crack between the rivets and their edges. Another reason for such cracking may be bulging caused by too much pressure by the riveting machine on the rivet. Sometimes such bulging is very apparent. A still further advance in practice is to punch one butt strap for each joint with small holes and use it as a template for drilling not only itself but the main plate and the other butt strap. Similarly, the holes in one plate of a circular seam may be punched small and used for a template for drilling the other holes. The best way, however, and the one which I hope to see adopted everywhere, is to drill all holes from the solid.

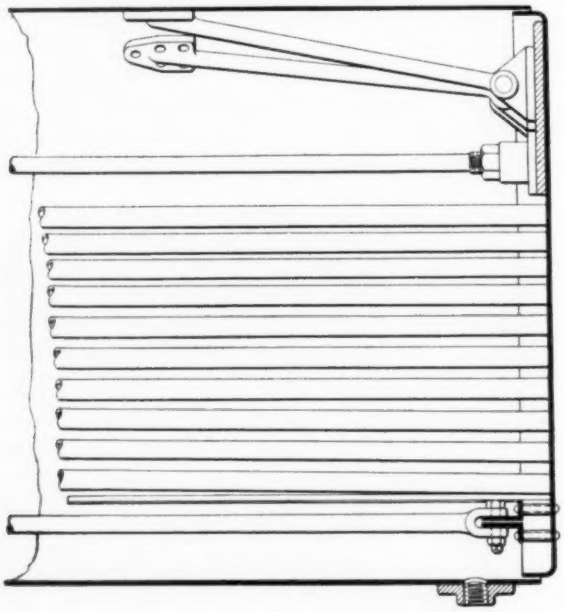

Fig. 4 Diagonal and Longitudinal Stays without Outside Nuts

I think it will be found that with proper tools this is the cheapest method.

The conical rivet head is being displaced by one of more or less spherical form which has the advantage over the former in having a thicker edge and increased holding power.

REINFORCING PLATES FOR THE OUTSIDE FIREBOXES OF VERTICAL BOILERS

Above the staybolt level of vertical boilers the outside fireboxes are subjected to the full stress that comes from the steam pressure, unreduced by any connection to the inside firebox by the staybolts. In some designs the whole outside firebox is made of the thickness required to stand the pressure as if unstayed; in other designs there is a short course of increased thickness just above the staybolts, and in still another design the outside firebox plate is thin for its whole height and is reinforced above the staybolts by riveting a band of steel around the inside of the plate.

I disapprove of the last of these methods and mention the fact here because the object of this paper is to point out the causes of boiler explosions and to advocate methods of construction that will reduce, if not do away with them. I have already stated that shell explosions are nearly always caused by the bending of the plates, and the inside reinforcing plates of vertical boilers, just described, can do no good without bending. They cannot then prevent the main plates from being overstrained, and they are therefore possible causes of explosions.

REVERSED FLANGES IN VERTICAL BOILERS

Still further in accordance with the object of this paper, I shall describe the action of that type of vertical boiler which is changed in diameter above the firebox by means of a reversed flange, Fig. 5. On account of the ease with which this flange bends, this type of boiler elongates when subjected to pressure, and, under test pressure, to a considerable extent. Even the pulsations in pressure coming from the opening and closing of the inlet valves of steam engines cause the boiler to change its length each time, and this action and others have caused many of the reversed flanges to crack. The effect has been reduced by making this flange of a less flexible form and increasing its thickness. It is not a good plan, however, to have flexible means of connecting the ends of boilers, and when the flange is made so thick that it is not flexible its object is no longer accomplished.

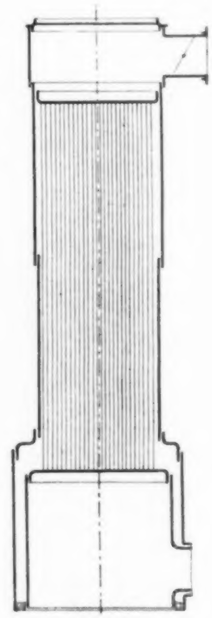

Fig. 5

Fig. 6

Fig. 5 Vertical Boiler with Reversed Flange

Fig. 6 Vertical Boiler with Conical Course

Another harmful effect of the elongation of boilers of this type is the bending of the lower tube plate upward and the upper one downward. This tends to pull the outer tubes from the tube plates and may cause explosions.

In order to obviate the two defects described, the reduction in diameter should be made, as it has been many times, by a conical course, Fig. 6, instead of by a reversed flange. An incidental advantage of this is that the circulation of the water is a little freer.

DISHED HEADS FOR STEAM DRUMS

Several explosions have been caused by dished heads cracking around the edges where they join the spherical portions. Apparently it has been thought by designers in general that if a head is pressed into spherical form and flanged, the radius being made equal to the diameter of the drum and the thickness equal to that of the drum, nothing more is necessary. There is no doubt, however, that such heads breathe and that

the cracking is due to this. It is the same phenomenon that causes the rupture of lap joints and breaks staybolts. I believe that such heads should be made of thinner plates than usual and braced like flat heads. The braces should be strong enough to carry the total pressure on the heads, and thin plates would stand the flanging process better than thick ones and with less liability of being injured at the corners.

In regard to the method of bracing such heads I am inclined to think that radial plate gussets would be best, and, if placed at equal distances completely around the drum, the latter would not be distorted by supporting the head. I think that anybody who has a boiler with unbraced drum heads should view them with anxiety.

FLUSH HEAD HORIZONTAL RETURN TUBULAR BOILERS

In New England, horizontal return tubular boilers are always built with the front tube plate flanged forward, but in other parts of the country it is frequently if not usually flanged backward. The latter is known as the *flush head* or *New York* boiler. I consider the New England method the better because all the riveting can be done by machine. With the other construction, one circular joint must be riveted by hand or pneumatically. Another advantage of the New England method is that it makes a tight smokebox, while the other, especially if the boiler has a brick smokebox, which is usually the case, is likely to leak air. A leaky smokebox diminishes draft and cools the gases, and thus diminishes the effect of an economizer if one is used.

The object of the flush head boiler is to have the joint between the front head and the shell plate always in contact with water so that if it is not protected by brickwork it will not be injured by heat. In the New England design, there is, however, no difficulty in keeping the joint protected, and there probably has never been a case of burning the joint.

BRICKWORK

Generally speaking, brickwork will stand without cracks in boiler settings unless it is pushed by the boiler; and it is only necessary to so place it, and have such details about the boiler, that it will not receive any serious pushing. The brickwork should not touch the boiler anywhere, and the space between it and the boiler should be stuffed with asbestos fibre. Although this filling may tend to leak air, the covering over the top of the boiler, which rests on the brickwork, prevents this. The front end of the boiler should be fixed, and the other end should have attached to it some back connection covering device which will slide and not tend to push the back wall over. Such a device has been made by Orosco C. Woolson, Mem. Am.Soc.M.E., and is reproduced in Fig. 7.

The vertical thickness of the brickwork on the sides of the boiler, and almost in contact therewith, should not, I think, be more than 12 in. It has been made 24 in., and in such cases I have seen the part raised bodily, apparently by the expansion of the boiler. This part of the brickwork is usually above the center of the boiler, but it should be equally above and below the center as thereby there is less chance of any of its weight being supported at all by the boiler. If the boiler supports it there is a chance that its weight will bend the plates, and the arguments against this have already been given.

It is common to use buckstays on the sides of boiler settings, but I also use them on front and back in order to prevent cracks. Buckstays should be usually of 8-in. I-beams of the lightest section, instead of cast iron which is unreliable.

USE OF AIR SPACES IN BOILER BRICKWORK

It has always been customary in this country to build the side and back walls of boiler settings with air spaces in order to diminish loss of heat by radiation. It is probable that these spaces cause loss of heat by convection and leakage, and it has been proved by experiments carried out by the United States Bureau of Mines (Bulletin 8) that this is true. If it is advisable to use spaces in the walls in order to prevent cracking of the brickwork, it is best to fill them with some material, such as ashes, crushed brick, sand or other loose material, which will entrap air but diminish its movement. Solid brick walls form a better non-conductor than walls with air spaces.

METHOD OF SUPPORTING HORIZONTAL RETURN TUBULAR BOILERS

The method of supporting horizontal return tubular boilers is of more importance than is usually realized. Such boilers, no matter what their length or size, should be supported at no

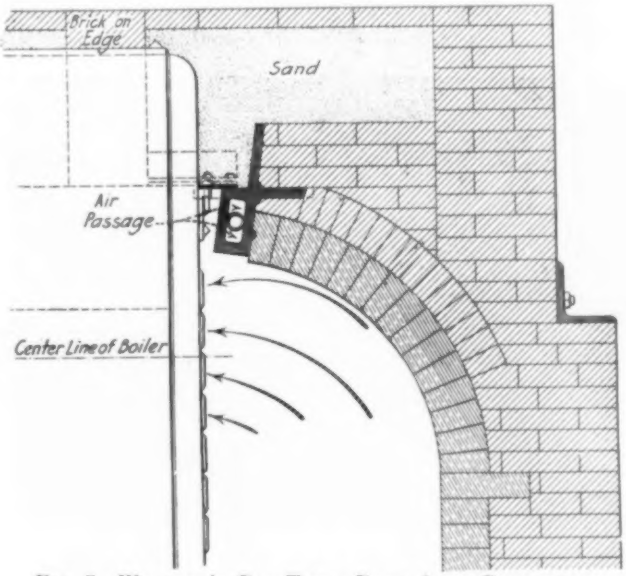

FIG. 7 WOOLSON'S GAS TIGHT BACK ARCH CONNECTION

more than four points. If boilers are long it is common to support them at six points. In order to prevent the end supports from leaving their bearings, springs are often placed under the middle brackets, but this does not render the pressures on the supports equal and is only a makeshift.

It is a principle in mechanics that if a body rests on three points the pressures on these points can be determined and will not change even if the points change their positions or levels. A 3-legged stool always rests properly on its legs, even when it rests on an irregular floor, but a stool with more than three legs never presses equally on each.

This shows that in supporting a horizontal boiler the three-point principle should be applied. To obtain this effect and yet have the boiler held up at four points, two points at one end are supported in the usual manner and the other two are connected by links to an equalizing lever working on a pin passing through overhead supporting beams. This was first done by Mr. Woolson, as described in a paper by him before the Society[1] in 1898. When a boiler is supported in this way the stress in the plates due to the weight can be made proper and will never change no matter how much the brickwork may settle, but if this system is not used the stress at one point may be sufficiently great to be a serious matter.

[1]Hanging and Setting of Horizontal Fire-Tube Boilers, O. C. Woolson, Trans.Am.Soc.M.E., Vol. 19, p. 781.

THE HEAT INSULATING PROPERTIES OF COMMERCIAL STEAM PIPE COVERINGS

BY L. B. McMILLAN, MADISON, WIS.
Junior Member of the Society

THERE are on the market at the present time a large number of commercial pipe coverings made up ready for use. It is customary to use one of these forms and for that reason, the investigations described in this paper are confined to such commercial coverings. However, as will be shown in the mathematical treatment of the subject, the results of the experiments confirm theoretical laws which may be used to extend the scope of the work so as to include the entire field of heat insulation.

An enormous amount of effort has been expended in attempts to determine accurately the savings effected by the use of non-conducting coverings on steam pipes. But, even with the results of all these investigations available, little reliable information is on hand regarding the efficiencies of pipe coverings in commercial use at the present time.

FIG. 1 APPARATUS USED FOR PIPE COVERING TESTS

FUNDAMENTAL METHOD OF TEST

It was proposed to heat a section of covered pipe by means of an electric heater made up of resistance coils immersed in oil inside the pipe, and to calculate the amount of heat lost through the covering by measuring the energy required to hold the outside metal of the pipe at a constant known temperature. Under such conditions it is evident that just enough energy is being supplied to compensate for the losses through the covering; otherwise the excess or deficiency of energy will cause the pipe to heat up or cool off as the case may be. This must be true for, according to the law of conservation of energy, all the energy entering must appear as heat since none is transformed into any other form and none is lost. Fig. 1 is a photograph of the apparatus used for the tests.

The objection will be raised that the results of the tests by this method do not represent actual operating conditions, since in actual practice the pipes contain steam and not hot oil. The conditions of operation in practice are these: The covering is placed on a pipe containing steam at some practically constant pressure; therefore the metal of the pipe has some definite constant temperature. The surrounding air may be either still or in motion, and it too has practically a constant temperature over a limited period. If the temperature of the pipe is higher than that of the air, or vice-versa, there will be a flow of heat, the quantity of which will be a function of the difference of temperature and certain constants, one of which is the conductivity of the material. Now it is so simple as to be considered axiomatic that this flow of heat will be independent of what the pipe contains so long as the temperature difference between the pipe surface and the air remains the same.

In order to maintain the temperature of the pipe constant, however, heat must be supplied from some source if heat is passing out through the covering. If steam is the heating medium the temperature gradient *inside* the pipe, that is, from the steam to the surface of the pipe, will be less than for oil; for the material having the higher conductivity will require the lower temperature gradient for the delivery of a given amount of heat. But the different effects of oil and steam will cease here.

The accuracy of any conductivity test depends upon being able to maintain constant conditions, and this may be done by electrical means better than by any other. It is necessary, however, to have a very accurate means of knowing not only when the temperatures are constant, but also the correct values of such temperatures. For room temperatures, high grade mercury thermometers were considered satisfactory. For the pipe temperatures, however, after a great deal of experimenting with various arrangements, it was decided to use copper-constantan thermo-couples and the potentiometer method of measuring the e.m.f. of the couples. The instruments were sensitive to about 0.2 deg. fahr. change of temperature, which was well within the requirements of the case.

TEMPERATURE GRADIENT INVESTIGATION

In the foregoing the fact was brought out that the drop in temperature from steam to the outside surface of a pipe was probably different than from oil to the same point on account of the different conductivities of these substances. The method of test provided for the measuring of the temperature of the *outside* of the pipe and not of the oil, so that in order to make the results applicable directly to steam conditions it is only necessary to establish a relation between the temperature of steam in a pipe and that of the outer surface of the pipe wall. This difference of temperature has been entirely neglected by most investigators, being accurately measured by none and considered not to exist by most.

With steam in the pipe, the temperatures of steam and of outside surface of pipe were measured very accurately. A photograph of the apparatus in use is shown in Fig. 2. The pipe P is arranged so that steam may be brought to it from the main at any pressure up to 130 lb. per sq. in. gage. The supply pipe is ½ in. in diameter, and for a distance of about 20 ft. it is left bare in order that no superheat due to the expansion of the steam would carry over into the test pipe. The small pipe p just below the test pipe is the drain, and a little steam was allowed to flow through it continuously in order that no air or water would collect in the test pipe.

The temperature measuring instruments are shown also. T is one of the thermo-couples on the outside of the pipe. L, L are the leads to the couples; the leads on the left go through the plug in the end of the pipe to a couple in the steam. I is an ice bath serving as the cold terminal of the couples. M is a slide wire potentiometer and a variable re-

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sistance is used in connection with it. C is a Weston standard cell, and B is a chloride accumulator or storage battery furnishing current for the potentiometer circuit. G is a very sensitive low resistance galvanometer.

Temperatures of steam and of outside of pipe were taken simultaneously at various steam pressures ranging from atmospheric to 130-lb. gage. This was done first with the pipe covered with one inch thickness of *Sectional 85 per cent magnesia* and later with pipe bare. In the first case from one to two hours' interval was allowed each time the pressure was changed for the temperatures to become constant before readings were taken, but the temperatures did not vary noticeably after the first few minutes. In case of the bare pipe only half an hour was allowed, for the temperature of the pipe surface reached its new value very quickly after the steam pressure was changed.

The results of the above described tests are given in the form of curves in Fig. 3*a* and *b*.

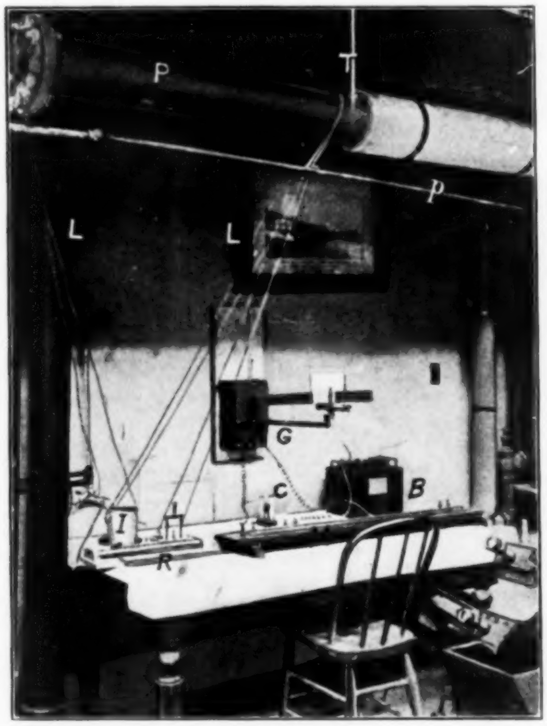

FIG. 2 APPARATUS FOR INVESTIGATING TEMPERATURE GRADIENT IN THE WALL OF A STEAM PIPE

The drop through the metal of the pipe was so small as to be difficult of accurate measurement, and it was therefore calculated from the temperature gradient required to cause a known amount of heat to flow through the wall of pipe.

The dotted curve, Fig. 3*b*, is constructed on the evidence given by a single test by Eberle.[1] It shows that the drop in temperature from steam to pipe is about ten times as great when the steam is superheated as when it is saturated at the same temperature. This accounts in a very large measure for the higher economy obtained by the use of superheat.

Fig. 4*a* is a section through the wall of a steam pipe showing the relative magnitudes of the temperature drops at various points when the pipe is not covered and its temperature is 300 deg. at the outside. Fig. 4*b* shows the same as the above for pipe covered with 1-in. of 85 per cent magnesia and for both saturated and superheated steam. This figure is of particular interest because it shows the effect of different substances in a pipe whose outside temperature is constant. The temperature gradient is greatly changed on the *inside* of the pipe, but not affected *outside*.

DESCRIPTION OF APPARATUS FOR TESTS OF COVERINGS

The general arrangement of apparatus used for the tests of pipe coverings is shown in Fig. 5. The test pipe is a 16-ft. section of standard 5-in. steel pipe closed at the ends and filled with gas engine cylinder oil. It contains also resistance coils which serve as an electric heater and a stirring device for

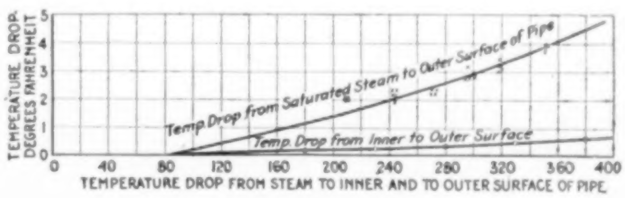

FIG. 3*a* COVERED PIPE

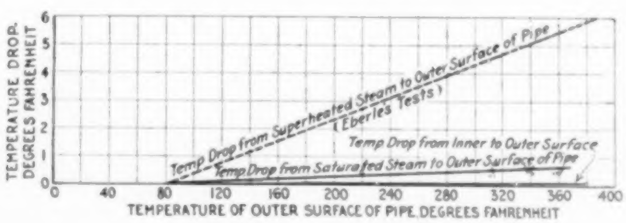

FIG. 3*b* UNCOVERED PIPE

FIG. 3 TEMPERATURE DROP FROM STEAM TO INNER AND OUTER SURFACES OF PIPE

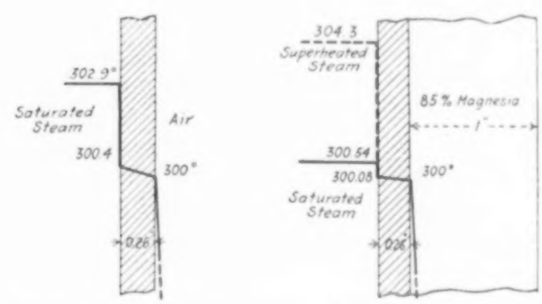

FIG. 4*a* UNCOVERED PIPE FIG. 4*b* COVERED PIPE

FIG. 4 TEMPERATURE DROP FROM STEAM TO OUTSIDE OF PIPE

keeping the oil in circulation. The remainder of the apparatus consists of the electrical instruments for measuring the energy input, a small electric motor for driving a circulating propeller in the pipe for keeping the oil in circulation, the thermometers for room temperature, and the thermo-couples and potentiometer for measuring the temperature of the pipe.

The fittings closing the ends of the large pipe are welded on to prevent the oil leaking out. At one end the pipe is closed by a cast iron cap welded to the pipe and at the other a flange is welded on and the end is closed by a blank flange bolted to the other with a gasket between. This blank flange has screwed into it the stuffing box for the shaft of the circulating propeller, two insulated terminals for the electric leads to the heating coils inside and a nipple leading to an overflow pipe which receives the oil expelled by the expansion of the large volume of oil that the test pipe contains. The arrangement of the stirrer and the electric leads may be seen in Fig.

[1] Mit über Forschungs-Arbeiten auf dem Geb. des Ing., heft 78.

5, and the overflow and the refilling chamber for keeping the pipe full of oil are shown in Fig. 6.

About 5 in. at each end of the test pipe is covered with *Sectional 85 per cent magnesia* 1-in. thick, leaving exactly 15 ft. of the central portion of the pipe as the test section, which will accommodate five lengths of standard pipe covering. The remaining surface of the ends is covered with *Plastic 85 per cent magnesia* to a depth of about an inch. The pipe is suspended in a horizontal position by wires from the ceiling attached to steel bands placed around the short end sections just described. These remained in place throughout the entire series of tests, and the only covering changed was the five lengths on the 15-ft. test section.

Since the covering of the ends was the same for all the tests of one inch coverings, some means of correcting for the losses through these end portions had to be devised. The device used in measuring the amount of this correction is the short pipe shown at the lower left hand corner of the upper diagram, Fig. 5. It is an exact reproduction of the permanently covered ends of the test pipe. Therefore, the difference between the loss from the test pipe and that from the short pipe represents the exact loss from the 15-ft. section covered with five standard lengths of commercial covering.

For the thickness tests, where thickness up to 3 in. were tested, the ends of the test pipe were covered with double standard thickness of *85 per cent magnesia* covering, and the short pipe was covered in the same way. A test was made on the short pipe under these conditions and the new end correction determined.

The thermo-couples are placed on the top, side, and bottom of the pipe, as shown in Fig. 5, and with this arrangement the average temperature of the outside of the pipe may be obtained with great accuracy. Each couple is imbedded in the metal of the pipe. A shallow hole, just large enough to admit the point forming the junction of the two metals of the couple, was drilled into the pipe, and after insertion the steel was forced down against this point by means of a center punch. The absolutely sure metal to metal contact secured in this way reduced to a minimum the chances for a drop in temperature from the metal of the pipe to the couple.

Direct current at 110 volts was used to supply the energy for the tests. It was obtained from a 25-kw. Curtis turbo-generator in the steam laboratory of the University of Wisconsin, and as the electric heater and the control rheostats were the only load on the machine, a very steady voltage was maintained.

In Fig. 5 is shown an instrument which gave warning of fluctuations of voltage. It consists of a solenoid in series with the heater coils, and a soft iron core hanging inside the solenoid at the short end of a balanced lever. This instrument is so sensitive that it may be relied upon to give warning of a change of voltage of 0.1 volt in either direction.

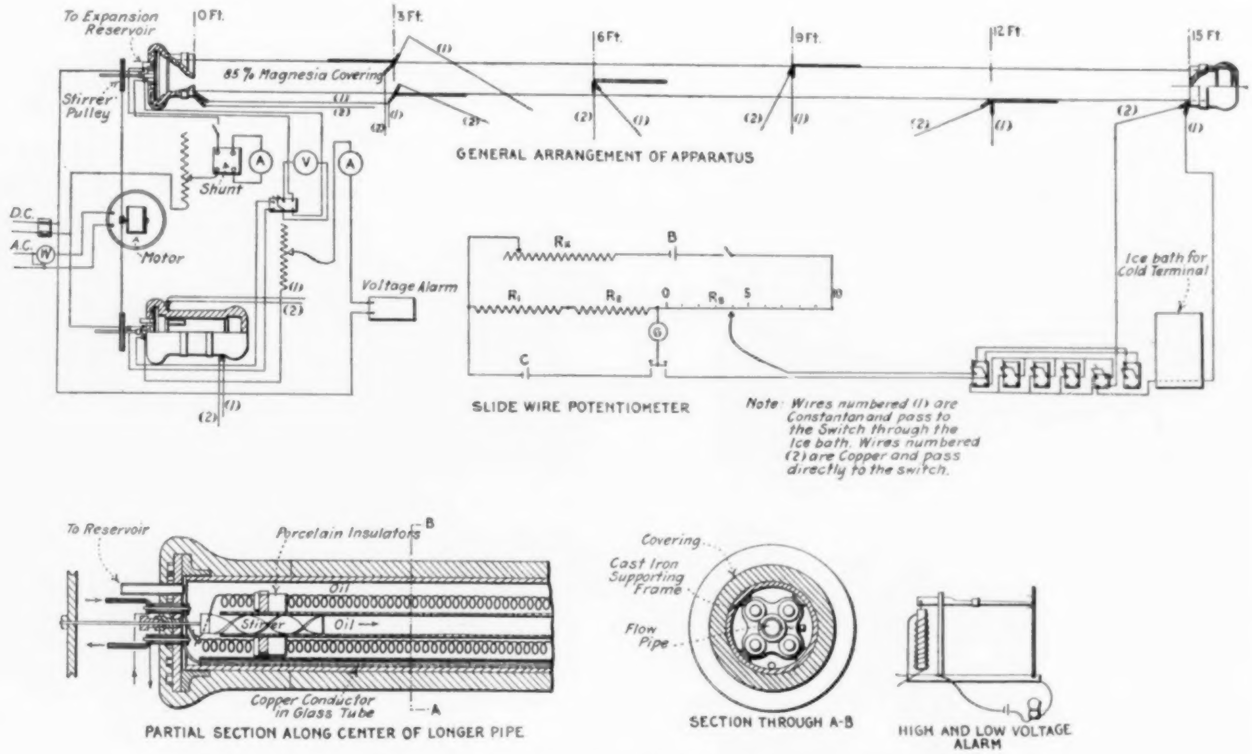

FIG. 5 APPARATUS FOR OBTAINING HEAT LOSSES THROUGH PIPE COVERINGS

For regulating the current, there is a wound wire rheostat with three coils which may be used either all in parallel with a capacity of 75 amp. or all in series for currents less than 25 amp. The finer adjustments are made by means of a small wire rheostat in series with a lamp bank and both in parallel with the large rheostat.

Fig. 7 shows the instruments and electrical control apparatus used in the tests.

METHOD OF PERFORMING THE TESTS

The coverings, before being tested for their heat insulating qualities, were placed on the steam pipe, Fig. 2, and allowed to dry for a week. Before being placed each was weighed and its thickness at each end was measured. The thickness so measured is called the actual thickness in the tables. The sections were fitted carefully. The circumferences of the bare pipe and of outside of all coverings were measured and from these data were calculated the apparent thicknesses of the

coverings, that is the distances from outside of pipe to outside of coverings. Where the covering was made up of soft sheets, as of felt, etc., pinned together, only the apparent thickness was measured.

A comparatively high current was passed through the pipe until it was heated to near the desired temperature, and then the current was lowered to such a value as would just hold the temperature of the outside of the pipe constant. When the temperature had remained practically constant for an hour, readings were taken of pipe temperature, room temperature, current in heater, and voltage across heater terminals. Then the current was diminished by about half an ampere and the temperature allowed to fall until it reached a value where the losses were just equal to this smaller amount of energy supplied, and readings were taken as before. The product of volts and amperes gave the energy in watts supplied to the heater. To maintain that current and voltage for one hour required an equal number of watt-hours, and the values of watt-hours were transformed into B.t.u. by multiplying by 3.413. The resulting losses in B.t.u. per hour were plotted against difference between temperature of outside of pipe and room temperature. Such a curve is shown in Fig. 8.

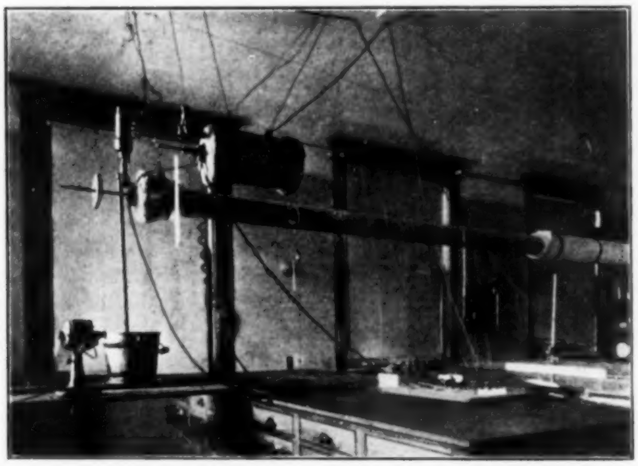

FIG. 6 VIEW OF SHORT PIPE AND FRONT END OF TEST PIPE

The three factors most important in determining the amount of heat that will be transmitted by a given insulating material are (1) the character of the material or, in other words, its conductivity; (2) the temperature difference between its two boundaries, and (3) the thickness of the layer of material. Two others of lesser importance are the character of the surface and the velocity of air fanning that surface. These last two were kept constant during all tests.

The character of materials was varied while temperature range and thickness were kept constant by making tests of 17 different pipe coverings of approximately the same thickness and subjected to the same temperatures. Tests were made at pipe temperatures ranging from 175 to 575 deg. fahr., and at least eight or ten tests were made on each material. The excellent agreement of so many tests on the same covering is the best indication of the accuracy of the work. For two different materials the thickness was varied from 0 to 3 in., while in each case material and temperature range were constant.

DESCRIPTION OF COVERINGS TESTED

All the coverings tested were bought on the open market. A brief description of each of the 26 coverings tested follows. The statements as to whether the covering was recommended for high or low pressure or superheated steam pipes were furnished by the manufacturers and are not conclusions drawn from the tests. The weight per foot in each case is the average weight per lineal foot of 5 in. covering, and the thickness given is the average thickness.

I *J-M 85 Per Cent Magnesia.* Molded sectional covering for high pressure steam pipes. 85 per cent by weight of magnesium carbonate and the remainder principally asbestos fiber. Weight per foot 2.92 lb. and thickness 1.08 in.

II *J-M Indented.* Layers of asbestos felt with indentations, about 1¼ in. in diameter and ⅛ in. deep, spaced very close to each other in staggered rows. For pipes containing high pressure steam. Weight per foot 3.46 lb. and thickness 1.12 in.

III *J-M Vitribestos.* Asbestos air cell covering made of alternate layers of smooth and corrugated vitrified asbestos

FIG. 7 VIEW OF INSTRUMENTS AND ELECTRICAL CONTROL APPARATUS

sheets. Corrugations about ¼ in. deep and run lengthwise of the pipe. For use on high pressure and superheated steam pipes and for stack linings, etc. Weight per foot 4.05 lb. and thickness 0.96 in.

IV *J-M Eureka.* For low pressure steam and hot water pipes. Made of ¼ in. of asbestos felt on the inside of the section and the balance of alternate layers of asbestos and wool felt. Weight 4.60 lb. per ft. and is 1.04 in. thick.

V *J-M Molded Asbestos.* Molded sectional covering for use on low and medium pressure steam pipes. Made of asbestos fiber and other fireproof material. Weight per ft. 5.53 lb. and thickness is 1.25 in.

VI *J-M Wool Felt.* A sectional covering made of layers of wool felt with an interlining of two layers of asbestos paper. May be used on low pressure steam and hot water pipes. Weight per ft. 2.59 lb. and thickness 1.10 in.

VII *Sall-Mo Expanded.* A covering for use on high and low pressure steam pipes. Made of eight layers of material, each consisting of a smooth and a corrugated piece of asbestos paper, the corrugations being so crushed down to form small longitudinal air spaces. Weight 3.47 lb. per ft., and thickness 1.07 in.

VIII *Carey Carocel.* Composed of plain and corrugated asbestos paper firmly bound together. Corrugations are approximately ⅛ in. deep and run lengthwise of the pipe. For use on medium and low pressure steam pipes. Weight 3.06 lb. per ft. and thickness 0.99 in.

IX *Carey Serrated.* For high pressure steam pipes. Composed of successive layers of heavy asbestos felt having closely spaced indentations. Weight 5.66 lb. per ft. and thickness 1.00 in.

X *Carey Duplex.* For low pressure steam and hot water pipes. Alternate layers of plain wool felt and corrugated asbestos paper firmly bound together. Corrugations run

lengthwise of the pipe and make air cells approximately ¼ in. deep. Weighs 1.79 lb. per ft. and 0.96 in. thick.

XI *Carey 85 Per Cent Magnesia.* For high pressure steam and similar in composition to No. I. Weight per foot 2.74 lb. and thickness 1.10 in.

XII *Sall-Mo Wool Felt.* Similar to No. VI except without interlining asbestos paper. For low pressure steam and hot water pipes. Weight per foot 3.73 lb. and thickness 1.01 in.

XIII *Nonpareil High Pressure.* Molded sectional covering consisting mainly of silica in the form of diatomaceous earth—the skeletons of microscopic organisms. For high pressure and superheated steam pipes. Weights 2.96 lb. per ft. and is 1.16 in. thick.

XIV *J-M Asbestos Fire Felt.* Asbestos fiber loosely felted together, forming a large number of small air spaces. For high pressure and superheated steam pipes. Weight per ft. 3.75 lb. and thickness 0.99 in.

XV *J-M Asbestos Sponge Felted.* Made from a thin felt of asbestos fiber and finely ground sponge forming a very cellular fabric. 41 of these sheets per in. thickness; air spaces are formed between the sheets in addition to those in the felt itself. Specially recommended for high pressure and superheated steam pipes. Weight per ft. 4.04 lb. and thickness 1.16 in.

XVI *J-M Asbestocel.* For medium pressure steam and heating pipes. Alternate sheets of corrugated and plain asbestos paper forming air cells about ⅛ in. deep that run around the pipe. Weight per ft. 1.94 lb. and thickness 1.10 in.

XVII *J-M Air Cell.* Corrugated and plain sheets of asbestos paper arranged alternately so as to form air cells about ¼ in. deep running lengthwise of the pipe. For medium pressure steam and heating pipes. Weight per ft. 1.55 lb. and thickness 1.00 in.

XVIII *½-In. J-M Plastic 85 Per Cent Magnesia.* For fittings, valves, irregular surfaces, boiler coverings, etc. Similar in composition to the sectional 85 per cent magnesia, but applied in the form of a cement or plaster. Thickness 0.51 in. for the first test and weight per ft. 1.51 lb.

XIX *1-In. J-M Plastic 85 Per Cent Magnesia.* Thickness 1.05 in., weight per ft. 3.33 lb.

XX *1½-In. J-M Plastic 85 Per Cent Magnesia.* Thickness 1.48 in., weight per ft. 5.23 lb.

XXI *2-In. J-M Plastic 85 Per cent Magnesia.* Thickness 1.99 in., weight per ft. 7.46 lb.

XXII *3-In. J-M 85 Per Cent Magnesia.* The two inches of plastic covering of No. XXI and one standard thickness layer of sectional covering outside of that. Thickness 3.24 in., weight per ft. 11.67 lb.

XXIII *½-In. Sall-Mo Air Cell.* Similar in composition and uses to No. XVII. Thickness 0.51 in. and weight per ft. 0.99 lb.

XXIV *1-In. Sall-Mo Air Cell.* Thickness 0.95 in., weight per ft. 1.57 lb.

XXV *2-In. Sall-Mo Air Cell.* Thickness 1.86 in., weight per ft. 3.58 lb.

XXVI *3-In. Air Cell.* Two inches of *Sall-Mo* and one inch of *J-M Air Cell.* Thickness 3.04 in., weight per ft. 6.66 lb.

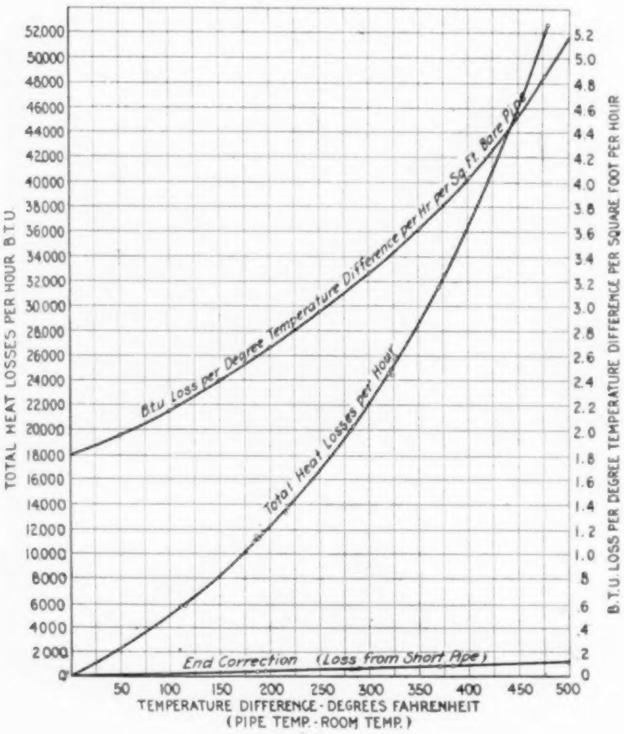

FIG. 8 TEST OF BARE PIPE

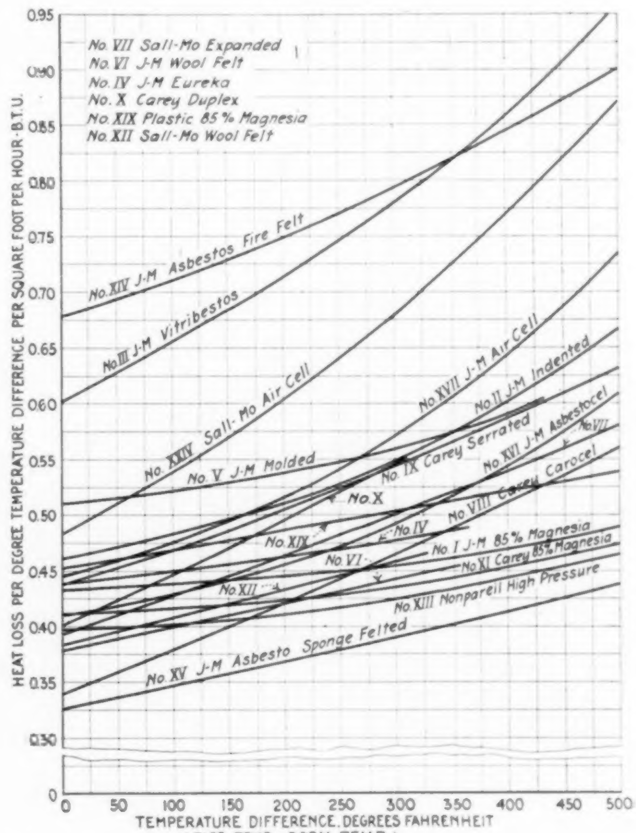

FIG. 9 SUMMARY OF RESULTS ON SINGLE THICKNESS COVERINGS

The total loss curve in Fig. 8 is plotted directly from the data obtained during the test. The ordinate of any point is the total heat loss per hour, which is the equivalent of the electrical energy required to maintain the pipe at the given temperature, and the abscissa is the difference between pipe temperature and room temperature. On the same sheet is plotted a curve of heat losses per hour from the short pipe at various temperature differences; this curve is called "end correction." The difference of ordinates between the two curves at any value of temperature difference gives the net heat loss per hour from the 15-ft. length of bare pipe. This net loss divided by the temperature difference and the area of test section (22.03 sq. ft.) gives the heat loss per degree temperature difference per square foot per hour.

The curve of net heat losses per degree temperature difference per square foot per hour is shown in Fig. 8 to a much larger scale. This curve shows that the heat loss per degree temperature difference is far from being a constant at all temperatures as has been assumed or implied by most former investigators.

According to Nusselt[1] the conductivity of many poorly conducting substances increases nearly as the absolute temperature instead of remaining constant. The tests described in the present paper establish the fact that the conductivity does not remain constant, but in no case except in that of the bare pipe did it increase quite as rapidly as the absolute temperature. Conductivity in this sense is rate of heat conduction per degree temperature difference per square foot per inch thickness per hour.

The net heat loss curves from all the tests of coverings 1 in. thick are assembled in the form of a general summary in Fig. 9. From the curves shown in this figure, one can tell at a glance what coverings are the more efficient at any temperature. Of all the coverings tested, the four best, at temperatures of 200 to 600 deg. fahr., are *J-M Asbestos-Sponge Felted, Nonpareil High Pressure, Carey 85 Per Cent Magnesia and J-M 85 Per Cent Magnesia*, ranking in the order named with the first well ahead of all the others. Those losing the greatest amount of heat were *J-M Vitribestos* and *J-M Firefelt*. The first of these latter is little used as a pipe covering, being employed mostly for stack linings, etc., while the virtue of the second is in its being a heat-proof material suitable for use as the layer in contact with a pipe carrying superheated steam, where the better insulating material used for the outer layers could not stand the temperature of superheat.

The saving in dollars per year due to use of covering has been calculated for each of the coverings tested and the results appear in Table 1. Also, the first cost of the covering is taken account of and values of net saving and per cent saving on investment are given for values of temperature differences of from 1 to 500 deg. fahr. The saving in B.t.u. per degree temperature difference per square foot per hour was first found for each temperature by subtracting from the bare pipe loss at that temperature the loss from covered pipe at same temperature. Then the total saving per square foot for a year of 365 twenty-four hour days was found by multiplying the saving per degree per hour per square foot by 8760 and by the temperature. The cost of heat was taken at $0.30 per million B.t.u., which is nearly equivalent to $0.30 per 1000 lb. of steam. The first cost of covering was ascertained from the manufacturers, and 10 per cent of list price was added for erecting and 10 per cent more for painting. The cost of covering *per year* was taken as 14 per cent of the total first cost, the 14 per cent including interest, depreciation, repairs, insurance, etc. The difference between the total saving per year and the cost of covering per year is the net saving per year.

The data in Table 1 have been plotted in the form of curves, shown in Fig. 10, for the first three coverings tested. All the data for the other coverings has been computed and any curve desired may be plotted in a very short time, by anyone wishing it.

The facts brought out by these curves are that the efficiency and saving increase with the temperature on account of more rapid increase, with temperature, of losses from bare pipe than of losses from covered pipe.

Fig. 11 shows the variation of losses with thickness at temperature difference of 100, 300 and 500 deg. fahr. and for thicknesses from 0 to 5 in. These curves were plotted from data calculated from the theoretical equation using constants determined in the tests. The points marked *o* are values from the actual experiments and they fall on the calculated curves with remarkable regularity except at the ½-in. and 3-in points. The ½-in. thickness cracked and checked considerably when heated up and this naturally decreased its insulating value, so that the values of losses would be greater than those calclated from the equation which made use of conductivities obtained at greater thicknesses where conditions were more nearly uniform. The outer one inch thickness on the test of 3-in. covering was not plastic, but was sectional magnesia covering which has a lower conductivity than the plastic.

Results of similar tests of different thicknesses of air cell covering, chosen because of their being representative of the two classes of materials—those with very small air spaces and those with rather large air spaces—are plotted in curve form in the paper.

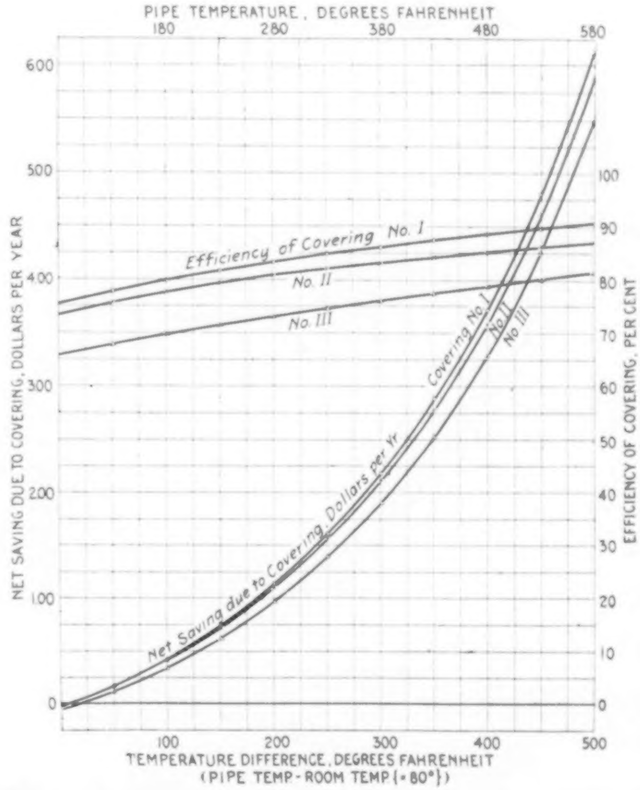

FIG. 10 EFFICIENCY AND NET SAVINGS CURVES FOR COVERINGS I, II, AND III

The net savings in dollars per year were calculated for various thicknesses of *J-M Sectional 85 Per Cent Magnesia* at temperature differences of 100, 300 and 500 deg. fahr. This was done in exactly the same manner as already described for single thickness coverings. These values were used in computing the cost per year of the various thicknesses of covering and results are given in Table 2. The curves for net savings per square foot per year in Fig. 11 show rapid increase in savings as the thickness is increased up to a point of maximum savings after which there is a decrease owing to the rapid increase in cost of covering. Fig. 11 shows the proper thickness for the maximum net saving at any temperature difference from 0 to 500 deg. fahr.

The chart for proper thickness mentioned above applied only to the case where steam costs $0.30 per 1000 lb. and is on 365 days in the year. Fig. 12 is a chart for proper thickness of magnesia covering to be used at any temperature, any price of steam and any number of hours service per year. The chart does not show values for length of service, but to use it for other periods than 365 days at 24 hours a day, multiply

[1] Zeit d. Ver. deut. Ing., vol. 52, p. 906.

TABLE 1 DATA ON EFFICIENCIES AND SAVINGS FOR SINGLE THICKNESS COVERINGS

Covering No.	Kind of Covering	Temperature Difference (Pipe and Room)	Actual Temperature (Room = 80 deg. fahr.)	B.t.u. Loss /Sq. ft./Deg. Temperature Difference/Hr.		B.t.u. Saving Due to Covering/Deg./Sq. ft./Hr.	Efficiency of Covering—Per Cent	Saving Due to Covering in B.t.u./Sq. ft./Yr.	Saving in $/Sq. ft./Yr.	First Cost of Covering/Sq. ft.	Cost of Covering/Sq. ft./Yr.	Net Saving in $/Sq. ft./Yr.	Interest on Investment
				Bare Pipe	Covered Pipe								
I	J-M 85% Magnesia	50	130	1.950	0.435	1.515	77.7	664,000	0.199	0.238	0.033	0.166	69.7
		100	180	2.152	0.438	1.714	79.6	1,502,000	0.451			0.418	175.5
		200	280	2.665	0.446	2.219	83.3	3,887,000	1.165			1.132	475
		300	380	3.260	0.455	2.805	86.1	7,370,000	2.212			2.178	914
		400	480	4.035	0.469	3.566	88.4	12,490,000	3.750			3.717	1560
		500	580	5.180	0.488	4.692	90.6	20,560,000	6.165			6.132	2575
II	J-M Indented	50	130	1.950	0.472	1.478	75.6	647,300	0.194	0.214	0.030	0.164	76.6
		100	180	2.152	0.483	1.669	77.6	1,462,000	0.438			0.408	190.5
		200	280	2.665	0.309	2.156	80.9	3,777,000	1.133			1.103	515
		300	380	3.260	0.549	2.711	83.2	7,120,000	2.136			2.106	983
		400	480	4.035	0.603	3.432	85.1	12,020,000	3.608			3.578	1676
		500	580	5.180	0.666	4.514	87.1	19,780,000	5.935			5.905	2760
III	J-M Vitribestos	50	130	1.950	0.626	1.324	67.9	580,000	0.174	0.381	0.053	0.121	31.8
		100	180	2.152	0.654	1.498	69.6	1,312,000	0.394			0.341	89.6
		200	280	2.665	0.715	1.950	73.2	3,417,000	1.025			0.972	255.0
		300	380	3.260	0.781	2.481	76.0	6,519,000	1.955			1.902	500.0
		400	480	4.035	0.856	3.177	78.8	11,130,000	3.340			3.287	865.0
		500	580	5.180	0.967	4.213	81.4	18,450,000	5.540			5.487	1442.0
IV	J-M Eureka	50	130	1.950	0.440	1.510	77.4	661,000	0.198	0.262	0.037	0.161	61.5
		100	180	2.152	0.451	1.701	79.0	1,490,000	0.447			0.410	156.6
		200	280	2.665	0.464	2.201	82.6	3,860,000	1.158			1.121	428.0
		300	380	3.260	0.478	2.782	85.4	7,310,000	2.192			2.155	824.0
		350	430	3.627	0.487	3.140	86.6	9,620,000	2.888			2.851	1090.0
V	J-M Molded	50	180	1.950	0.517	1.433	73.4	627,600	0.188	0.190	0.027	0.161	55.5
		100	180	2.152	0.522	1.630	75.8	1,428,000	0.428			0.401	211.0
		200	280	2.665	0.539	2.126	79.8	3,725,000	1.117			1.090	574.0
		300	380	3.260	0.561	2.699	82.8	7,088,000	2.126			2.099	1105.0
		400	480	4.035	0.596	3.439	85.2	12,050,000	3.615			3.588	1888.0
VI	J-M Wool-Felt	50	130	1.952	0.386	1.564	80.2	684,700	0.205	0.214	0.030	0.175	81.8
		100	180	2.152	0.400	1.752	81.4	1,535,000	0.460			0.430	201.0
		200	280	2.665	0.421	2.244	84.2	3,930,000	1.179			1.149	537.0
		300	380	3.260	0.442	2.818	86.4	7,400,000	2.220			2.190	1023.0
		350	430	3.627	0.453	3.174	87.6	9,730,000	2.919			2.889	1349.0
VII	Sall-Mo Expanded	50	130	1.950	0.409	1.541	79.0	674,600	0.202	0.248	0.035	0.167	67.3
		100	180	2.152	0.427	1.725	80.2	1,511,000	0.453			0.418	168.5
		200	280	2.665	0.464	2.201	82.6	3,856,000	1.156			1.121	452.0
		300	380	3.260	0.503	2.757	84.6	7,240,000	2.172			2.137	852.0
		400	480	4.035	0.541	3.494	86.6	12,240,000	3.672			3.637	1466.0
		500	580	5.180	0.581	4.599	88.8	20,140,000	6.042			0.007	2421.0
VIII	Carey Carocel	50	130	1.950	0.358	1.592	81.6	697,000	0.209	0.195	0.027	0.182	93.4
		100	180	2.152	0.378	1.774	82.4	1,555,000	0.467			0.440	226.0
		200	280	2.665	0.421	2.244	84.2	3,932,000	1.180			1.153	592.0
		300	380	3.260	0.466	2.794	85.7	7,340,000	2.202			2.175	1116.0
		400	480	4.035	0.510	3.525	87.4	12,350,000	3.705			3.678	1886.0
		500	580	5.180	0.562	4.618	89.2	20,220,000	6.066			6.039	3100.0
IX	Carey Serrated	50	130	1.950	0.454	1.496	76.7	655,000	0.197	0.214	0.030	0.167	78.0
		100	180	2.152	0.468	1.684	78.2	1,475,000	0.443			0.413	193.0
		200	280	2.665	0.506	2.159	81.0	3,782,000	1.135			1.105	517.0
		300	380	3.260	0.546	2.714	83.3	7,132,000	2.140			2.110	986.0
IX	Carey Serrated	400	480	4.035	0.587	3.448	85.4	12,075,000	3.622			3.592	1680.0
		500	580	5.180	0.634	4.546	87.8	19,900,000	5.970			5.940	2780.0
X	Carey Duplex	50	130	1.950	0.423	1.527	78.3	669,000	0.201	0.162	0.023	7.178	110.0
		100	180	2.152	0.447	1.705	79.2	1,494,000	0.448			0.425	252.0
		200	280	2.665	0.498	2.167	81.3	3,798,000	1.139			0.116	689.0
		300	380	3.260	0.548	2.712	83.2	7,128,000	2.140			0.117	1307.0
		350	430	3.627	0.574	3.053	84.2	9,360,000	2.808			2.785	1720.0
XI	Carey 85% Magnesia	50	130	1.950	0.413	1.537	78.8	673,000	0.202	0.200	0.028	0.174	87.0
		100	180	2.152	0.418	1.734	80.5	1,519,000	0.456			0.428	214.0
		200	280	2.665	0.424	2.241	84.1	3,929,000	1.179			1.151	576.0
		300	380	3.260	0.436	2.824	86.6	7,420,000	2.226			2.198	1099.0
		400	480	4.035	0.454	3.581	88.8	12,550,000	3.765			3.737	1869.0
		500	580	5.180	0.472	4.708	90.9	20,610,000	6.183			6.155	3078.0
XII	Sall-Mo Wool-Felt	50	130	1.950	0.395	1.555	79.8	681,000	0.204	0.190	0.027	0.177	93.3
		100	180	2.152	0.401	1.751	81.4	1,535,000	0.461			0.434	228.0
		150	230	2.400	0.421	1.979	82.5	2,600,000	0.780			0.753	396.5
		200	280	2.665	0.433	2.232	83.8	3,910,000	1.173			1.146	604.0
		250	330	2.951	0.455	2.506	84.9	5,484,000	1.645			1.618	852.0
		300	380	3.260	0.459	2.801	85.9	7,360,000	2.208			2.181	1150.0
XIII	Nonpareil High Pressure	50	130	1.950	0.399	1.551	79.5	679,000	0.204	0.224	0.031	0.173	77.2
		100	180	2.152	0.402	1.750	81.3	1,533,000	0.460			0.429	92.0
		200	280	2.665	0.412	2.253	84.6	3,950,000	1.185			1.154	516.0
		300	380	3.260	0.426	2.834	86.9	7,448,000	2.234			2.203	985.0
		400	480	4.035	0.444	3.591	89.0	12,580,000	3.774			3.745	1673.0
		500	580	5.180	0.465	4.715	91.0	20,640,000	6.190			6.159	2752.0
XIV	J-M Fire Felt	50	130	1.950	0.694	1.256	64.4	550,000	0.165	0.333	0.047	0.118	35.4
		100	180	2.152	0.711	1.441	67.0	1,262,000	0.379			0.332	99.7
		200	280	2.665	0.749	1.916	71.9	3,360,000	1.008			0.961	288.6
		300	380	3.260	0.795	2.465	75.6	6,480,000	1.944			1.897	570.0
		400	480	4.035	0.845	3.190	79.0	11,175,000	3.353			3.306	993.0
		500	580	5.180	0.901	4.279	82.6	18,740,000	5.620			5.573	1675.0
XV	J-M Sponge Felted	50	130	1.950	0.336	1.614	82.7	707,000	0.202	0.333	0.047	0.165	49.5
		100	180	2.152	0.347	1.805	83.8	1,581,000	0.474			0.427	128.0
		200	280	2.665	0.369	2.296	86.2	4,035,000	1.211			1.164	350.0
		300	380	3.260	0.391	2.869	88.0	7,540,000	2.262			2.215	665.0
		400	480	4.035	0.414	3.621	89.8	12,690,000	3.809			3.762	1132.0
		500	580	5.180	0.439	4.741	91.5	20,770,000	6.230			6.183	1860.0
XVI	J-M Asbestocel	50	130	1.950	0.418	1.532	78.5	671,000	0.201	0.262	0.037	0.164	62.7
		100	180	2.152	0.429	1.723	80.0	1,510,000	0.453			0.416	159.0
		200	280	2.665	0.454	2.211	83.0	3,876,000	1.163			1.126	430.0
		300	380	3.260	0.493	2.767	84.8	7,272,000	2.181			2.144	820.0
		400	480	4.035	0.544	3.491	86.5	12,230,000	3.670			3.633	1388.0
		500	580	5.180	0.609	4.571	88.2	20,020,000	6.006			5.969	2280.0
XVII	J-M Air Cell	50	130	1.950	0.459	1.491	76.4	655,000	0.196	0.190	0.027	0.169	89.0
		100	180	2.152	0.475	1.677	77.9	1,469,000	0.441			0.414	218.0
		200	280	2.665	0.515	2.150	80.7	3,769,000	1.130			1.103	581.0
		300	380	3.260	0.571	2.689	82.7	7,066,000	2.120			2.093	1101.0
		400	480	4.035	0.643	3.392	84.1	11,885,000	3.568			3.541	1865.0
		500	580	5.180	0.733	4.447	85.8	19,475,000	5.841			5.814	3060.0

the price of steam by the number of hours per year the steam line considered is in service and divide by 8760 and, using the result as the price of steam on the chart, find the proper thickness.

MATHEMATICAL TREATMENT OF HEAT FLOW IN INSULATING MATERIALS

The problem of insulating objects against the flow of heat is one which, when the necessary constants are known, is capable of very complete mathematical solution, but the mathematical treatment cannot take the place of all experimental work, since the conductivities of the materials must be determined by actual experiment; but once these are known, further tests are not required for the accurate determination of the losses from any thickness whatsoever.

TABLE 2 DATA ON EFFICIENCIES AND SAVINGS OF VARIOUS THICKNESSES OF 85 PER CENT MAGNESIA COVERING

Temperature Difference	Thickness	B.t.u./Sq. ft./deg. dif./hr.			Saving	Efficiency	Total Saving/yr.		First Cost of Covering	Cost of Covering/yr.	Net Saving
		Bare Pipe	Plastic 85 per cent Magnesia	Sectional 85 per cent Magnesia			B.t.u.	Dollars (Steam at 30c/1000 lb.			
100	0.5	2.152	0.735	0.691	1.461	67.8	1,280,000	0.384	0.125	0.018	0.366
100	1.0		0.492	0.462	1.690	78.4	1,481,000	0.444	0.238	0.033	0.411
100	2.0		0.319	0.300	1.852	85.5	1,622,000	0.486	0.341	0.048	0.438
100	3.0		0.248	0.233	1.919	89.1	1,681,000	0.504	0.528	0.074	0.430
100	4.0		0.209	0.196	1.956	90.8	1,714,000	0.514	0.851	0.119	0.395
100	5.0		0.185	0.174	1.978	91.9	1,733,000	0.520	1.215	0.170	0.350
300	0.5	3.260	0.805	0.757	2.503	76.8	6,579,000	1.975	0.125	0.018	1.957
300	1.0		0.524	0.493	2.767	84.9	7,270,000	2.181	0.238	0.033	2.148
300	2.0		0.335	0.315	2.945	90.4	7,740,000	2.322	0.341	0.048	2.274
300	3.0		0.260	0.244	3.016	92.5	7,922,000	2.377	0.528	0.074	2.303
300	4.0		0.219	0.206	3.054	93.7	8,026,000	2.408	0.851	0.119	2.289
300	5.0		0.192	0.181	3.079	94.4	8,090,000	2.427	1.215	0.170	2.257
500	0.5	5.180	0.895	0.842	4.338	83.7	19,000,000	5.700	0.125	0.018	5.682
500	1.0		0.557	0.524	0.656	89.9	20,410,000	6.125	0.238	0.033	6.092
500	2.0		0.350	0.329	4.851	93.6	21,260,000	6.380	0.341	0.048	6.332
500	3.0		0.273	0.257	4.923	95.0	21,570,000	6.470	0.528	0.074	6.396
500	4.0		0.229	0.215	4.965	95.8	21,750,000	6.525	0.851	0.119	6.406
500	5.0		0.199	0.187	4.993	96.4	21,880,000	6.560	1.215	0.170	6.300

In the case of flat surfaces, where the two boundaries of the insulating material are parallel planes, the application of the mathematical treatment is very simple. In this case the quantity of heat conducted is given by the equation

$$Q = k \frac{\theta_1 - \theta_2}{x} A\, t \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

in which Q is the quantity of heat conducted, θ_1 and θ_2 the temperatures of hotter and colder surfaces respectively, x is the thickness in in. of the layer of material, A is the area in sq. ft. of the surface considered, t is the time in hr. and k is the conductivity of the material in B.t.u. per degree temp. difference per sq. ft. per in. thickness per hour. The reason for strange mixture of feet and inches in the equation is the irrational definition, in the English units, of conductivity, since in it the square foot is made the unit of area and the inch the unit of thickness.

The tests of pipe coverings now under discussion involved cylindrical surfaces rather than flat ones, so that a more extensive explanation will be made of this class of problems. The rate of heat flow through the material of a pipe is given by the equation

$$W_1 = \frac{k(\theta_1 - \theta_2)}{r\,(\log_e r_2 - \log_e r_1)} \ldots\ldots\ldots\ldots\ldots [2]$$

in which W_1 is the rate of heat flow per sq. ft. of pipe per hr.; k is the conductivity; θ_1 and θ_2 are the temperatures; r_1 and r_2 are the radii of the inner and outer surfaces of the pipe respectively, and r is the outside radius of the pipe. The entire equation is rational and contains nothing of empirical nature except the conductivity, k, which must be determined by experiment. The data obtained from the tests described in the paper form an excellent basis for the calculation of these conductivities.

Below is given an example of the computation of the conductivity, k. The material is *J-M 85 Per Cent Magnesia;* temperature difference between pipe surface and air is 300

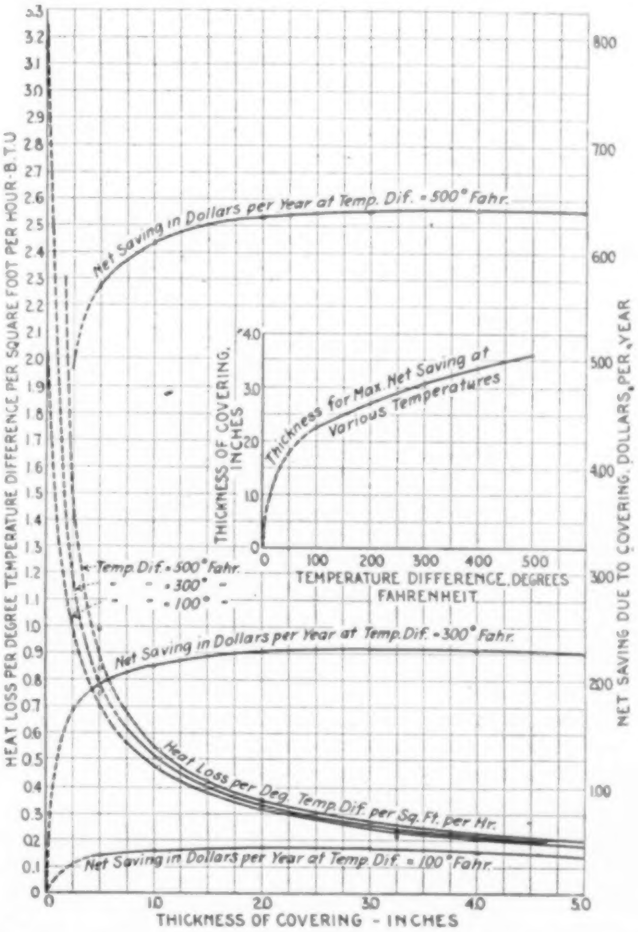

FIG. 11 THICKNESS-SAVINGS CHART FOR 85 PER CENT MAGNESIA COVERINGS

deg. fahr.; thickness of covering, 1.13 in.; outside diameter of pipe, 5.6 in. The rate of heat loss per degree temperature difference per square foot per hour is found from Fig. 9 to be 0.455 B.t.u. Therefore, W_1, the total loss per sq. ft. per hr., is equal to $300 \times 0.455 = 136.5$ $W_2 = 136.5 \times 2.8 \div (2.8 + 1.13) = 97.2$ B.t.u.

From the curve, Fig. 13, the temperature difference between outer covering surface and air corresponding to a loss of 97.2 B.t.u. is 65 deg. Therefore, the temperature difference between inner and outer covering surfaces is $(300 - 65) = 235$ deg.

$$k = \frac{W_1\, r\,(\log_e r_1 - \log_e r_2)}{\theta_1 - \theta_2}$$

$$= \frac{136.5 \times 2.8\,(\log_e 3.93 - \log_e 2.8)}{235}$$

$$= 0.551$$

The conductivity of *J-M 85 Per Cent Magnesia* at 300 deg

temperature difference is therefore 0.551 B.t.u. per deg. temp. difference per sq. ft. per in. thickness per hr.

Conductivities have been calculated at 300 deg. temp. difference (pipe temperature—room temperature) for all of the coverings tested. The values are given in Table 3. This table is the best basis on which to compare coverings, because here all differences due to different thicknesses are done away with and the coverings may be compared under exactly the same conditions.

For finding the heat loss through any thickness of any material of which the conductivity is known, and at any temperature difference between pipe and room up to 500 deg. fahr., a modification of equation [2] may be used.

CONCLUSION

In conclusion it may be said that in most cases it pays to use the best commercial pipe covering obtainable; because

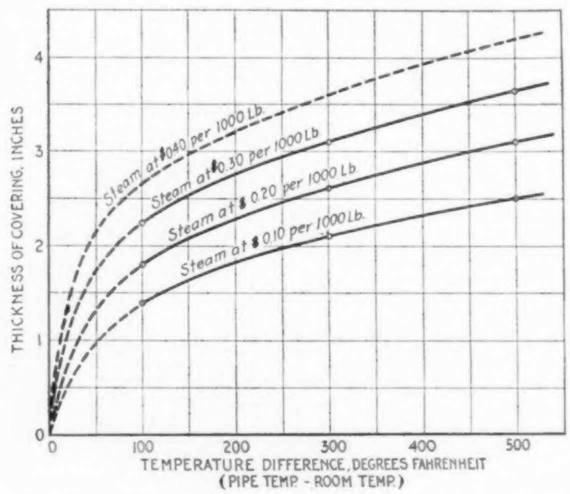

FIG. 12 CHART FOR DETERMINING PROPER THICKNESS OF 85% MAGNESIA FOR MAXIMUM NET SAVINGS AT VARIOUS TEMPERATURES AND PRICES OF STEAM

where the material is paid for many times over during the first year by the saving effected by its use, the first cost loses much of its weight as a determining factor in the selection of type of covering to be used. In view of the results of the thickness tests, it is a deplorable fact that few steam lines at the present time are provided with thick enough a covering for the greatest net saving. However, where fuel is cheap and the lines are in use only a small percentage of the time, the cheaper coverings have their advantages. Also there are places, as on some heating systems, where the heat lost through the coverings is not wasted and the object of covering the pipes at all is to keep tunnels, etc., cool enough that men may work in them. Therefore, a careful study of conditions is necessary before a certain type of covering can be recommended for a given piece of work. However, it is hoped that the data given in this paper will be of assistance to engineers in deciding upon the material to be used under certain con-

TABLE 3 CONDUCTIVITIES OF PIPE COVERINGS AT 300 DEGREES TEMPERATURE DIFFERENCE BETWEEN PIPE SURFACE AND ROOM

No.	Kind of Covering	Conductivity
I	J-M 85 Per Cent Magnesia	0.551
II	J-M Indented	0.686
III	J-M Vitribestos	1.087
IV	J-M Eureka	0.549
V	J-M Molded Asbestos	0.778
VI	J-M Wood Felt	0.521
VII	Sall-Mo Expanded Asbestos	0.598
VIII	Carey Carocel	0.540
IX	Carey Serrated	0.682
X	Carey Duplex	0.636
XI	Carey 85 Per Cent Magnesia	0.546
XII	Sall-Mo Wool Felt	0.510
XIII	Nonpareil High Pressure	0.543
XIV	J-M Asbestos Fire Felt	1.093
XV	J-M Asbestos Sponge Felted	0.468
XVI	J-M Asbestos Cell	0.596
XVII	J-M Air Cell	0.718
XVIII to XXII	Plastic 85 Per Cent Magnesia	0.587
XXIV	Sall-Mo Air Cell	0.802

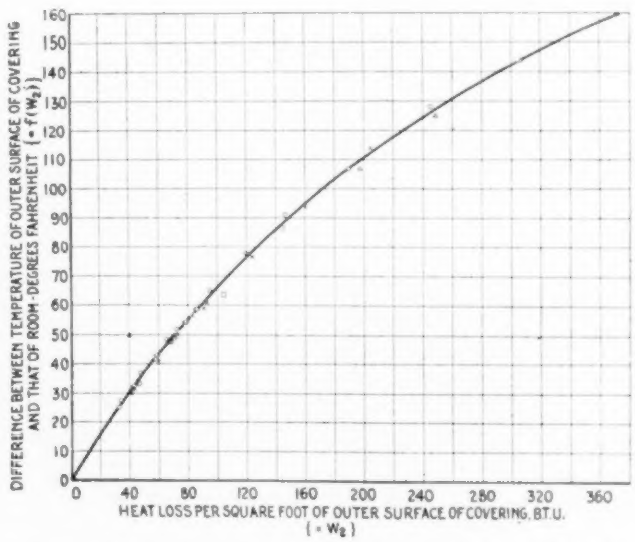

FIG. 13 CURVE SHOWING RELATION OF HEAT LOSSES TO TEMPERATURE

DIFFERENCE BETWEEN COVERING SURFACE AND SURROUNDING AIR

ditions, and in calculating heat losses on installations already in use.

The durability of materials used for pipe coverings is a very important factor in determining the most economical covering for a given set of conditions. It has already been pointed out that the proper basis for comparing costs was the cost per year and not the first cost of the material. This is true because the covering giving the greatest length of service for a given first cost and efficiency is obviously the one to select. In general, fibrous coverings are more durable than the molded forms; since the latter tend to revert to their original powdered state due to vibration and rough usage, while those made of fibrous material firmly felted together show no such tendency.

CIRCULATION IN HORIZONTAL WATER TUBE BOILERS

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Junior Member of the Society

WITH high combustion rates and high furnace temperatures, the load on boiler surfaces exposed directly to the fire is very intense. For a furnace temperature of 2500 deg. fahr. and a boiler temperature of 400 deg. fahr., the rate of radiation per square foot of boiler surface is about 100,000 B.t.u. per hr.; for 2750 deg. fahr., 150,000 B.t.u., and for 3000 deg. fahr., 200,000 B.t.u., corresponding approximately to loads of 100, 150 and 200 lb. of steam per sq. ft. respectively, whereas the load averaged for all the surface in a boiler is usually only 3.5 to 10 lb. per sq. ft.

It is important that the tubes subjected to these loads have ample circulation of water, and be kept clean of scale as well, otherwise the resistance to heat transfer on the water side of the tube will increase, causing an increase in the temperature of the metal, which, if high enough, will result in rupture. An increase in tube temperature will also decrease the heat absorbed by radiation and reduce the efficiency. It is only in the region of these tubes that the velocity of circulation can have any appreciable effect on the efficiency of heat absorption.

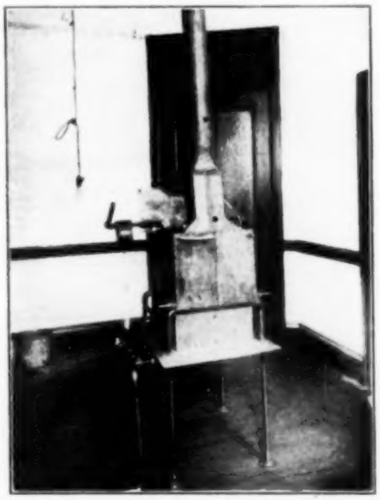


FIG. 1 MODEL BOILER SET UP FOR TEST WITH METAL COVER PLATES ON FRONT AND GLASS COVER PLATES ON REAR, AS SHOWN IN FIG. 2

In a simple U-tube circuit without resistance, the velocity of a homogeneous mixture would be $v = \sqrt{2 g H}$ where H is the head measured in terms of the steam-water mixture. The velocity may also be expressed in terms of the total volume of steam and water circulating, the cross section and time, giving the expression:

$$v = \phi \sqrt[3]{\frac{V h}{A}}$$

where V is the volume of steam per hour, h the distance from center of heating of tube to water level, A is the cross section area and ϕ is a coefficient dependent on slip and resistance. This expression indicates that, if the coefficient remained constant, the velocity would increase as the cube root of the steam volume or load, that is, if the load were doubled the velocity would increase 1.26 times. But this condition does not exist, except in the frictionless U-tube circuit without slip, and is far from being attained throughout the entire circuit of commercial boilers.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members, 20 cents to non-members.

MODEL BOILER FOR STUDYING CIRCULATION

In order to study circulation and the nature of the flow in different types of horizontal boilers, a model was constructed as shown in Figs. 1, 2 and 3.

The boiler was built in two units, each complete with drum headers and tubes. There were 75 half-inch outside diameter No. 18 B. & S. brass tubes about 2 ft. long, of a total surface of 17 sq. ft. in each unit. The headers were rectangular as in an Edge Moor boiler, and by inserting suitable strips of brass the design could be changed to represent the different constructions of Figs. 4*A* to 4*F*. Glass covers were placed on the front and back headers to permit observation of conditions and the taking of photographs. Rubber packing formed of split rubber tubing was placed on the edge of the strips under the glass.

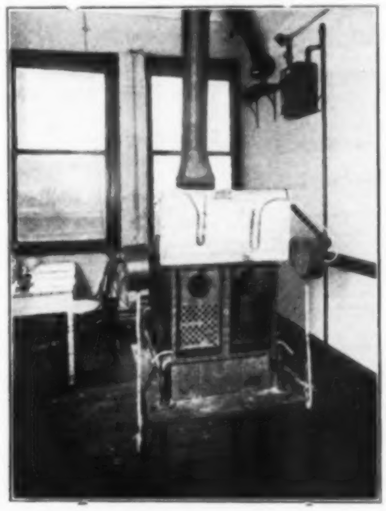


FIG. 2 VIEW OF MODEL BOILER, SHOWING OUTLET PIPES WITH SEPARATORS ON EACH HALF OF THE BOILER AND GAGES FOR MEASURING OUTPUT

The boiler was set with a slope of 1 in. to the foot over a gas furnace consisting of three large burners capable of burning 200 cu. ft. of gas per hr. One-inch asbestos lined the furnace and boiler casing. The baffling for the gases was of the parallel type in two passes. The boiler was set so that the gases entered at the rear of the bottom pass, Fig. 3*a*, and also with the relative position of furnace reversed, the gas entering the first pass directly in front, as shown in section of Fig. 3*b*. An induced draft fan drew the gases through the boiler.

PHOTOGRAPHS OF THE BOILER CIRCULATION

Photographs of the moving steam and water in the headers were taken at a speed of approximately 1/100 sec. with flashlight illumination.

When the circulation is poor and steam is slipping through the water the latter shows up transparent and the header appears almost empty, whereas where the steam and water are well mixed or emulsified, there is a distinct whitish color and marked contrast in the photographs.

Before a photograph was taken, the water was brought to the same level in each header without having the burners on. The level was slightly below the bottom of the drum in the front header as shown in Fig. 14.

Wherever bubbles of steam appear to be at rest in the photographs, it may be assumed that their velocity was no more than 1 ft. per sec., while streaks indicate higher velocities.

Steam was generated at atmospheric pressure and the volume was measured by orifices in the outlet pipes on each half of the boiler. As the volume of steam at atmospheric pressure is very great compared to that at 200 lb. (for example) a low load in pounds per square foot per hour on the model corresponds to a high load in terms of steam volume. The equivalent loads given in connection with the pictures are based on a boiler pressure of 200 lb., at which the steam volume is about 0.08 that at atmospheric pressure.

A greater proportion of the steam was generated in the bottom tubes. The relative loads in different rows was probably about the same as the average in an actual boiler, wherein the distribution varies considerably depending on the furnace temperature.

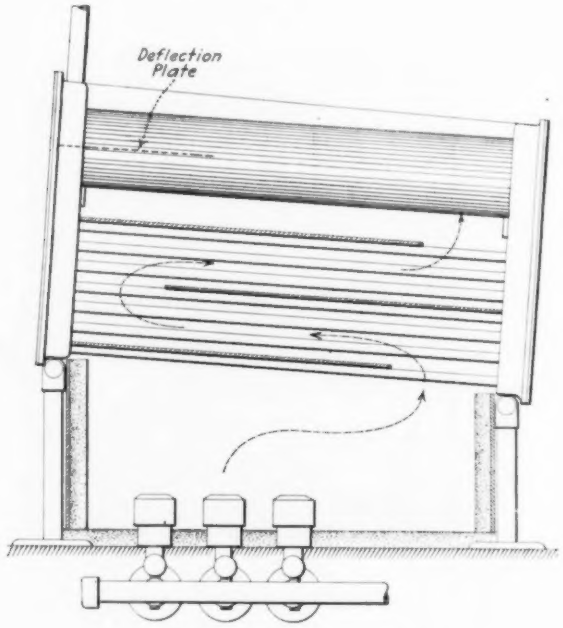


FIG. 3a MODEL WATER TUBE BOILER

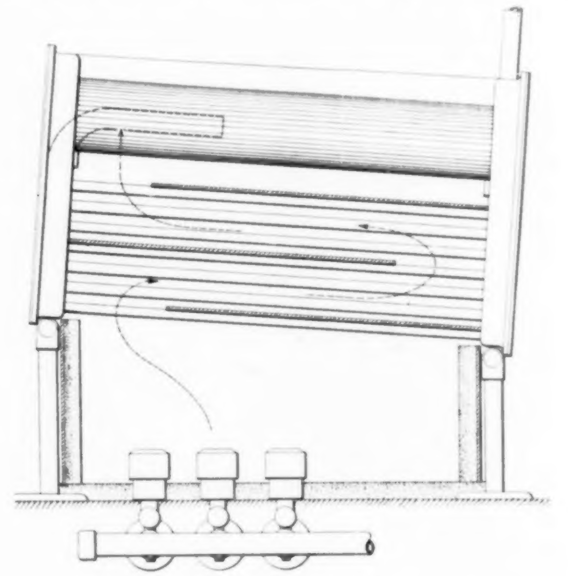


FIG. 3b MODEL WATER TUBE BOILER

Fig. 5 shows the circulation in the front headers at about 85 per cent of rating. On the left is a header with a flue for increasing circulation in the bottom tubes, and on the right the square header.

In the left hand half of Fig. 5, the greater evaporation is obviously taking place in the bottom tubes connected into the circulation flue where there is a well directed upward flow. The upper tubes of the boiler discharge into their compartments of the header very quietly and the steam slips up through the water and is liberated in the header. The pumping action, as in an air lift, is shown clearly in the central flue. The discharge is vigorous enough to strike the horizontal deflection plate in the center of the drum.

The right hand half of Fig. 5 illustrates how slip occurs in a header of relatively large area; the steam slips up through the water and is liberated largely in the header as indicated by the wide belt of foam formed at the surface of the water, which is to be contrasted with the quiescent conditions on the left. The steam and water issued from the bottom tubes as a homogeneous mixture filling the bore of the tubes and preserved this state as it turned up, but after a short distance it seemed to be absorbed by the comparatively large mass of water in the header. The tubes carrying lighter loads discharged steam and water from the upper part of the tube only.

A rotary flow can be seen in the square header, Fig. 5. The current rises at the left and falls at the right, the velocity being low or next to nothing where the bubbles can be distinguished.

Fig. 6 was taken at the same load but with low water level to show the effect of the circulation flue in the left hand boiler. The bottom tubes of this boiler are discharging water and steam up the flue into the drum, whereas no water is delivered to the drum from other sections of the header or from the header on the right hand side. Return circulation occurs through the upper tubes.

Fig. 7 shows the boilers steaming at approximately 275 per cent load and Fig. 8 about 450 per cent load. The upper tubes of the left hand boiler are now working more actively, but the relatively small amount of steam generated is indicated by the fact that about half the rows of tubes can be seen through water, especially in Fig. 7, the steam slipping through without causing a flow of water. The flow in the circulation flue is smooth and full bore. On the right there is violent commotion with whirls and swirls in all directions. The steam and water rise nearly to the top of the drum which indicates the head needed to make the turn and discharge the mixture into the drum.

Fig. 9 shows the lower right hand corner of the same type header to a larger scale, steaming at an equivalent load of 250 per cent. The circulation is upward on the left and downward on the right. The rush of circulation to the left of the header is presumably due to the fact that the heat is greatest in the center of the furnace, which corresponds to the left hand side of this header.

Fig. 10 shows Heine type headers in both parts of the boiler and double circulation flues on the left, these rising along the sides of the header in extensions which did not connect with any upper boiler tubes. No heavy mixtures were therefore discharged into the light steam water emulsion rising from the bottom tubes. The load was about 275 per cent. The discharge of the upper tubes of the left hand boiler slips through the water and the mixture in the center, near the top, is moving slowly, whirling in all directions. The right hand picture illustrates again the tendency for internal circulation in an open header; there is a marked rotary flow and downward

current on the right. A closer study of the figure will show what seem to be light shadows to the left of the tube ends in the bottom row. This is the discharge of steam slipping through the water. Fig. 11 shows the same boiler steaming at 500 per cent load.

Fig. 12 shows the Heine type header on the right and the single circulation flue on the left, at about 450 per cent load. The white streak across the right hand header is a cemented crack in the glass. Numerous small eddy currents or whirls can be distinguished. Bubbles that are nearly stationary are distinguishable all along the lower section, directly in the center and in the upper right hand corner—these forming the vortex of a whirl in a clockwise direction.

Fig. 13 shows a third arrangement of circulation baffle with three flues on the left, and a Babcock and Wilcox type header on the right; the load was about 450 per cent. Fig. 14, at no load, shows the construction of the header more clearly. The flow in the sections of the Babcock and Wilcox header was directly upwards, with no cross currents or whirls and only a slight sinuous movement, but was throttled by the nipples at the top of each section. Stationary bubbles can be distinguished in many of the headers. At low loads the slip through the headers was similar to that in the previous types, the

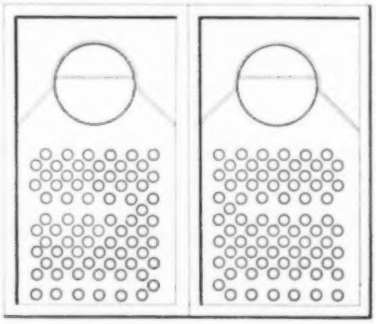


Fig. 3c Model Water Tube Boiler

bubbles rising through the water without causing discharge from the nipples.

Fig. 15 is a view of the rear headers when steaming at the same rate. The left hand header (corresponding to the Babcock and Wilcox type on the right in front) is boiling backward from the upper tubes, causing a fluctuating and higher water level. The white mark across the bottom of the right hand drum is caused by the splashing of the water against the glass.

Fig. 16 shows the rear headers at about 85 per cent load, a slight boiling back being noticeable here also. This figure shows another feature, however—the left hand drum is dry due to the poor circulation of the front headers into the drum, whereas the right hand drum is receiving water which can be seen emptying into the rear header. The steam slips through the water in the front headers on one side, without pumping water into the drum. The true water levels are equal, but about 3 in. low.

Reversal of boiling also occurred with other types of headers. Fig. 17 shows the boilers with front headers as in Fig. 10, steaming at 85 per cent. A number of tubes can be seen to be discharging steam. This occurred intermittently and would appear first at one tube and then another. Fig. 18 shows the rear of the boilers shown in front in Fig. 12 steaming at about 300 per cent load.

The back boiling was eliminated by reversing the boiler setting, that is, setting the boiler over the furnace so that the opening at the end of the lower horizontal baffling came at the front and higher end of the boiler, near the front header, as shown in Fig. 3*b*.

Fig. 19 shows the rear headers when the boiler was set in this manner, and the load was about 450 per cent. The rear headers were perfectly clear, and no discharge occurred from any of the tubes. The front headers were of the design shown in Figs. 5 to 9, which figures were also taken with the flow of hot gases entering the tube nest at the front.

Figs. 20 and 21 show the rear headers with the same setting, but with the Babcock & Wilcox type header at the front of the left hand boiler and the design of Fig. 4*C* at the front of the right hand boiler. The nipples of the sectional header were reduced one half in area by inserting sleeves. Fig. 20

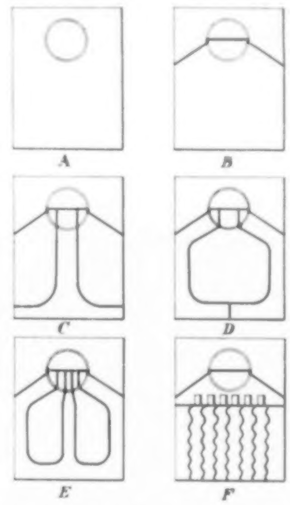


Fig. 4 Different Types of Headers Tested

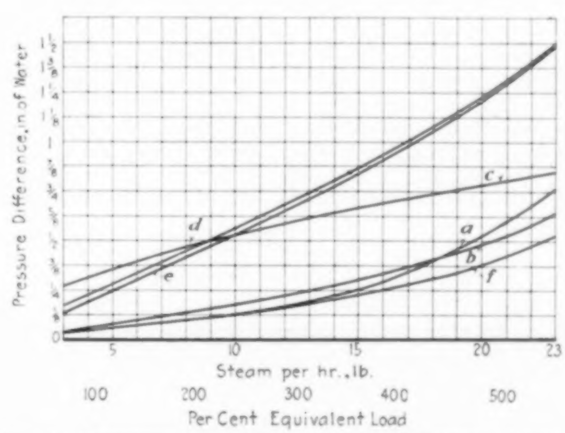


Fig. 22 Pressure Difference Tests, Headers 4*A* to 4*F*

shows a load of 300 per cent. While the true water levels were exactly the same, the left hand header shows a higher surface and also considerable commotion at the surface, due to reversal of circulation through the upper tubes. The water level fluctuated up and down with a swing of several inches. Fig. 21 shows the same boilers with 85 per cent load. The true water levels were equal but when steaming the level in the left hand unit fluctuated, rising and backing up the water in the drum and then falling.

In addition to the above tests on circulation, a series of tests was made in which the difference in pressure between the bottoms of the front and rear headers was measured. Curves in Fig. 22 show the results obtained. The letters in the figure correspond to the letters in Fig. 4. The circulation flues increase the pressure difference front and rear of the bottom

tubes and add to the circulation created in the tube itself due to the slope.

Boiling back, particularly from the upper tubes, takes place if the discharge area at the junction of header and drum is constricted.

CONCLUSIONS

Increased circulation in the lower rows of tubes of a horizontal boiler can be obtained by constructions which segregate the discharge from those tubes up through the front header into the drum, and by designing the circuit to prevent slip and to offer the least resistance, particularly at the entrance to the drum.

The velocity of circulation of a steam-water mixture increases about as the square root of the steam volume or load.

The volume of water circulated increases at first as the steam volume increases, reaches a maximum, and then decreases. The maximum load on a tube should not exceed that coincident with maximum water delivery.

The tendency for reversal of circulation is lessened by setting the boiler so that the gases strike the tube bank at its higher end.

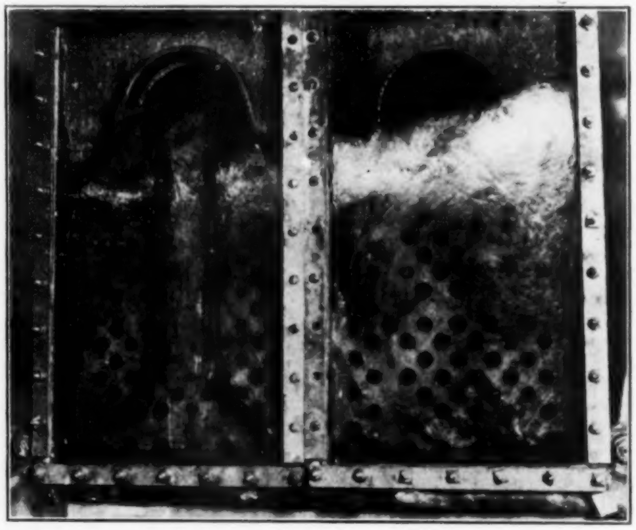


FIG. 5 FRONT HEADERS; LOAD 85 PER CENT; SETTING AS IN FIG. 3b

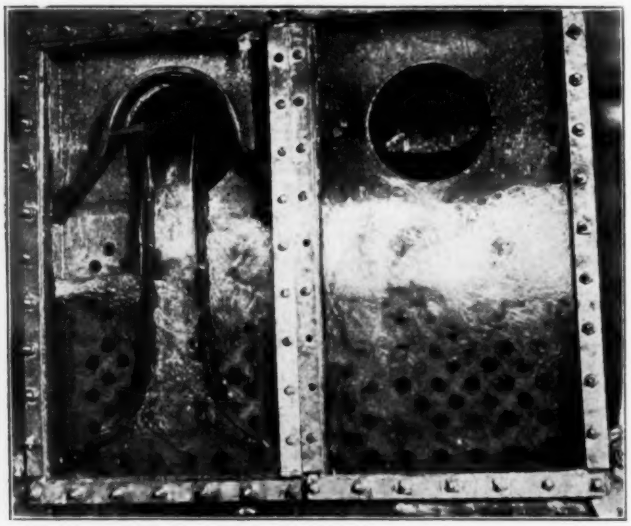


FIG. 6 FRONT HEADERS; LOAD 85 PER CENT; SETTING AS IN FIG. 3b; WATER LEVEL BELOW NORMAL

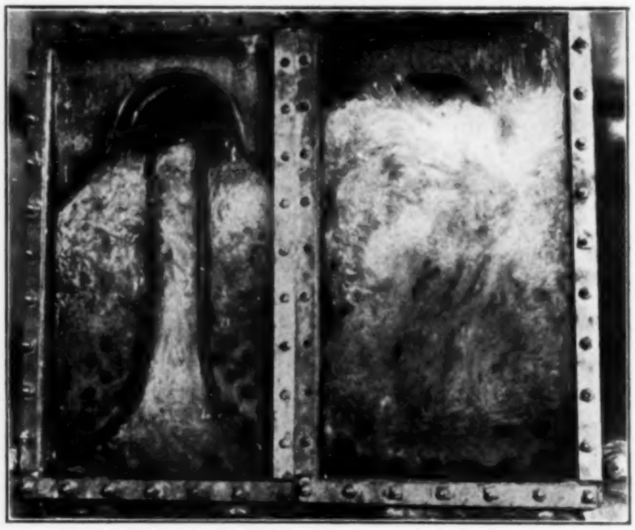


FIG. 7 FRONT HEADERS; LOAD 275 PER CENT; SETTING AS IN FIG. 3b

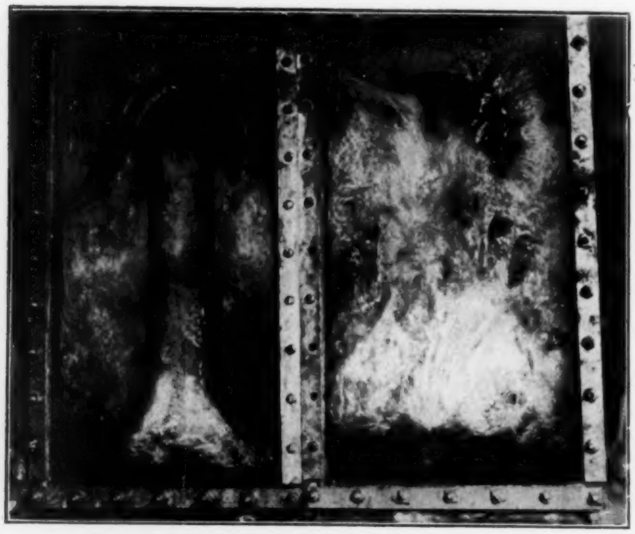


FIG. 8 FRONT HEADERS; LOAD 450 PER CENT; SETTING AS IN FIG. 3b

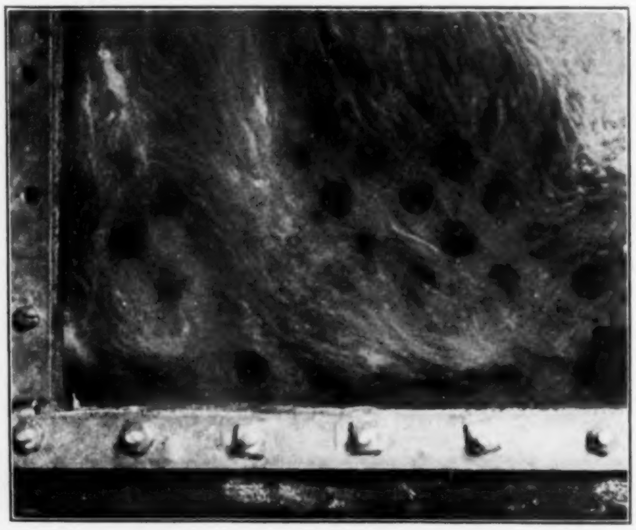


FIG. 9 LOWER SECTION OF SAME BOILER AS IN FIG. 8; LOAD 250 PER CENT; SETTING AS IN FIG. 3b

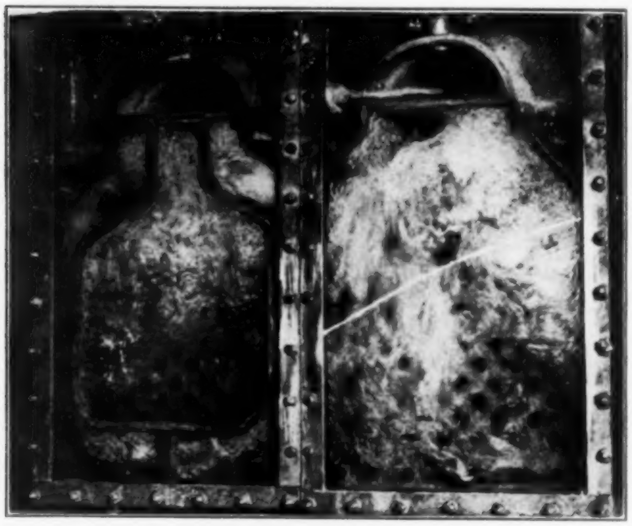


FIG. 10 FRONT HEADERS; LOAD 275 PER CENT; SETTING AS IN FIG. 3a

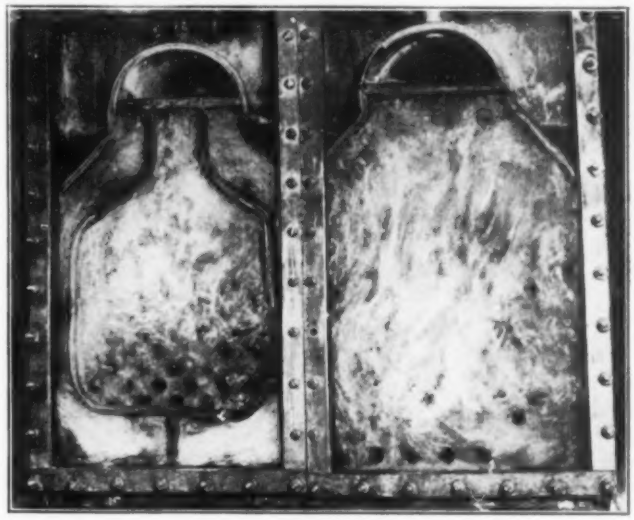


FIG. 11 FRONT HEADERS; LOAD 500 PER CENT; SETTING AS IN FIG. 3a

FIG. 12 FRONT HEADERS; LOAD 450 PER CENT; SETTING AS IN FIG. 3a

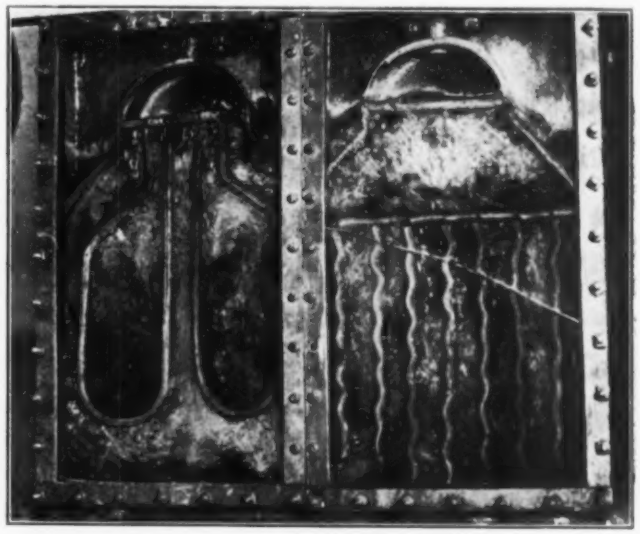


FIG. 13 FRONT HEADERS; LOAD 450 PER CENT; SETTING AS IN FIG. 3a

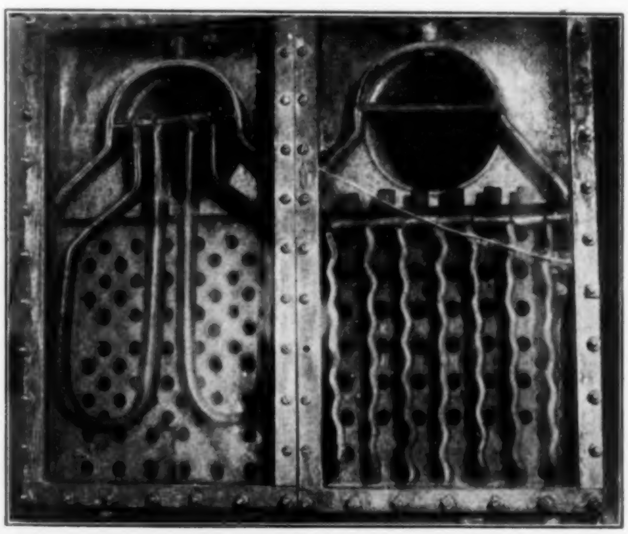


FIG. 14 BOILERS WITHOUT LOAD SHOWING TRUE WATER LEVELS 1 IN. BELOW BOTTOM OF DRUM IN FRONT HEADERS, AND 1 IN. ABOVE IN REAR HEADERS

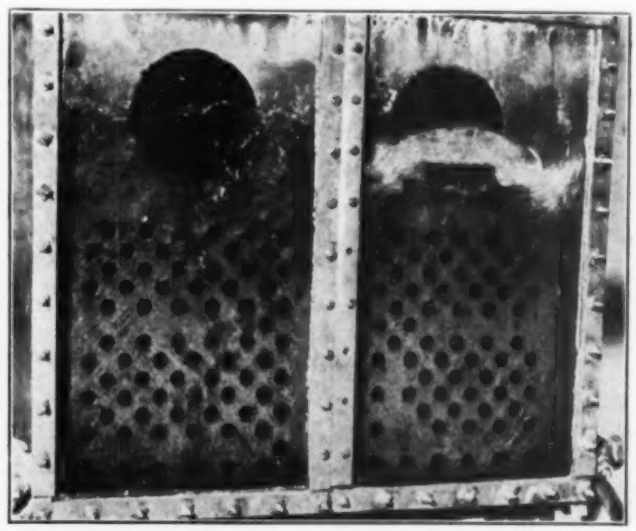


FIG. 15 REAR HEADERS CORRESPONDING TO HEADERS OF FIG. 13 IN FRONT; LOAD 450 PER CENT; SETTING AS IN FIG. 3a

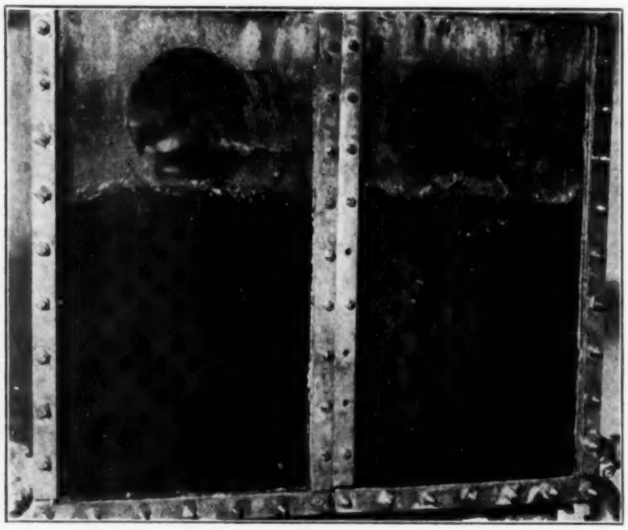


Fig. 16 Rear Headers Corresponding to Headers of Fig. 13 in Front; Load 85 Per Cent; Setting as in Fig. 3a

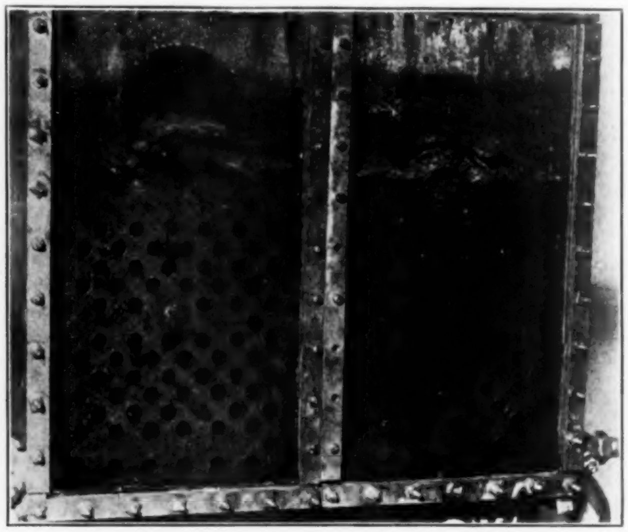


Fig. 17 Rear Headers Corresponding to Design of Fig. 10 in Front; Load 85 Per Cent; Setting as in Fig. 3a

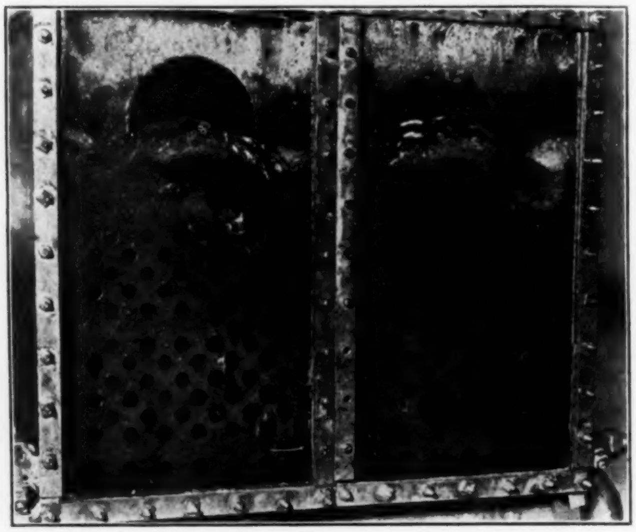


Fig. 18 Rear Headers Corresponding to Design of Fig. 12 in Front; Load 300 Per Cent; Setting as in Fig. 3a

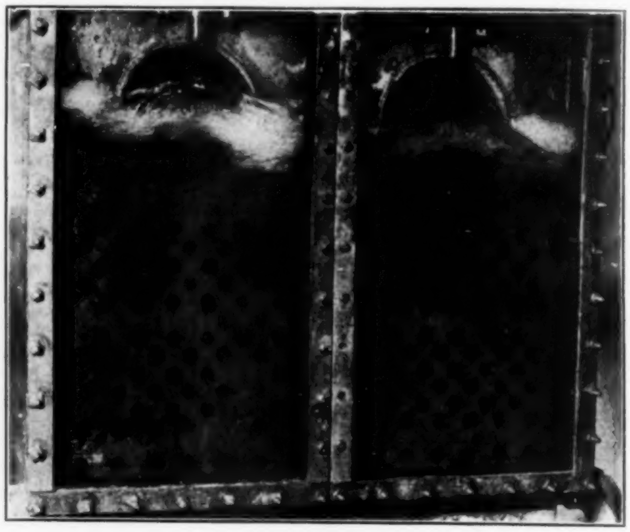


Fig. 19 Rear Headers Corresponding to Design of Fig. 5 in Front; Load 450 Per Cent; Setting as in Fig. 3b

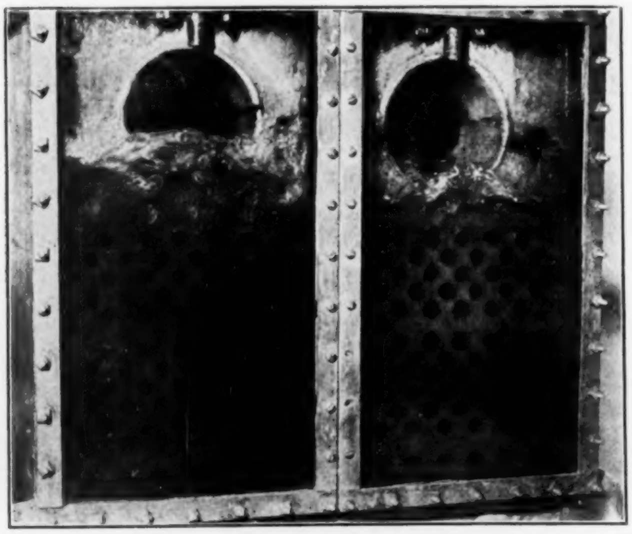


Fig. 20 Rear Headers Corresponding to Design of Fig. 4F and 4C in Front; Load 300 Per Cent; Setting as in Fig. 3b

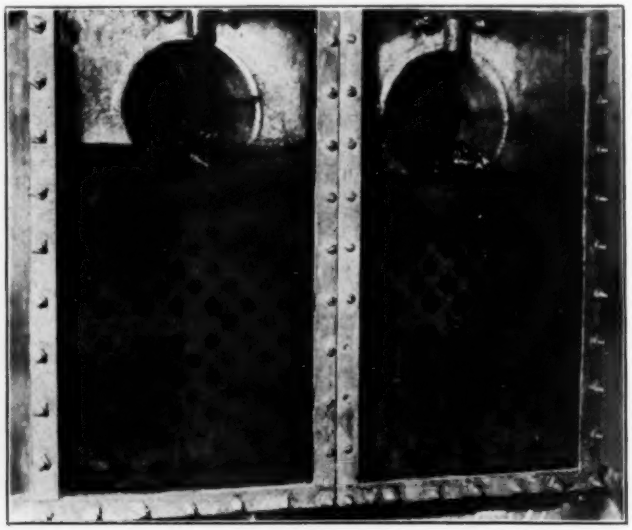


Fig. 21 Showing Rear Headers, same as in Fig. 20; Load 85 Per Cent; Setting as in Fig. 3b

PERFORMANCE AND DESIGN OF HIGH VACUUM SURFACE CONDENSERS

BY GEO. H. GIBSON, NEW YORK

Member of the Society

AND

PAUL A. BANCEL, NEW YORK

Junior Member of the Society

THE coefficient of heat transmission in an experimental condenser filled with pure steam appears from recent investigations to be a determinate quantity dependent upon steam temperature, water velocity, diameter of tube and mean water temperature and its value is of the order of 500 to 1500 B.t.u. per sq. ft. per hr. per deg. fahr. difference. In the commercial condenser the high rate of transmission undoubtedly existing for certain parts of the surface is masked by the large amount of relatively idle surface, so that the average coefficient for all the surface figures out much lower—sometimes as low as 50 B.t.u. The size and cost of a condenser to maintain a certain vacuum depend primarily on the extent of the zone of active condensation, that is, on how much of the surface does work and how much is idle. As will be shown, the problem is one of hydrodynamics as well as of heat transmission.

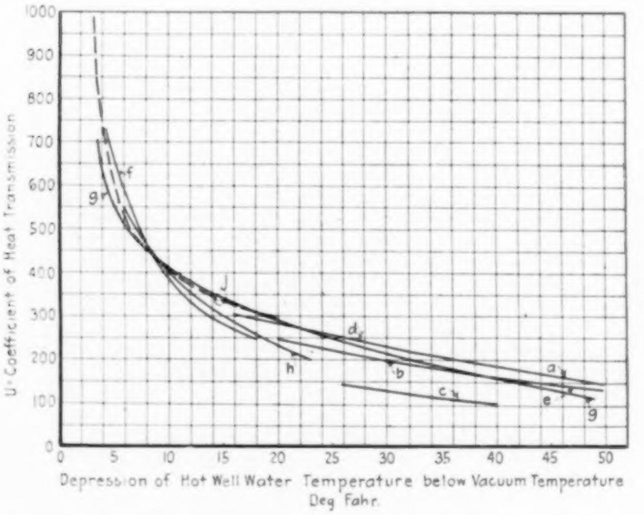


FIG. RELATION BETWEEN COEFFICIENT OF HEAT TRANSFER AND TEMPERATURE DEPRESSION

These variations being commonly attributed to the presence of air and to imperfect stream distribution and penetration, modern high vacuum surface condensers are equipped with large capacity air pumps and are designed with liberal areas for the flow of steam through the tube bank, with the minimum depth of tube bank between inlet and outlet. When careful attention is also given to excluding air in leakage, high vacuums are successfully maintained. However, a condenser which will give a high coefficient of heat transfer when the test readings are taken under summer conditions with circulating water at temperatures of 70 to 80 deg. fahr., will also give relatively low values in winter with cold water; the warmer the water and the lower the vacuum, the smaller the mean temperature head required to transmit practically constant amount of heat through the surface.

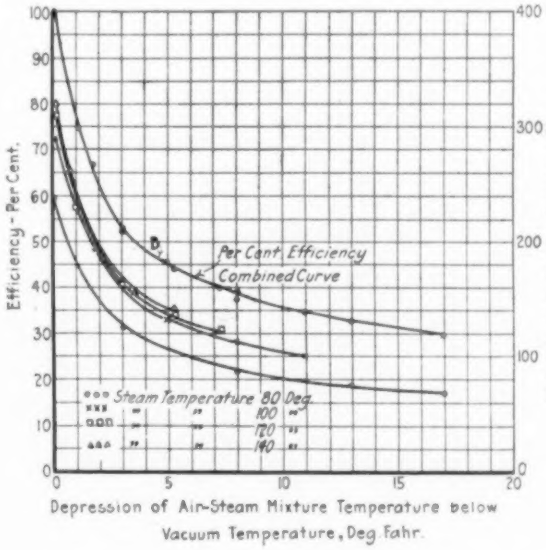
Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December, 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members, 20 cents to non-members.

DEPRESSION OF AIR PUMP SUCTION TEMPERATURE AS AN INDEX OF SURFACE EFFICIENCY

Examination of the results of a number of tests on commercial condensers, a vacuum evaporator, and a laboratory condenser indicates a definite relation between the coefficient of heat transfer and the difference between the steam temperature at the condenser inlet and the air temperature at the outlet.

The water velocity, mean water temperature and tube diameter affect the rate of transmission from the tube wall to the water, that is, the transmission on the *water side* of the tube, and their individual influences have been determined in experimental single tube condensers, so that corrections for these variables can be applied with a reasonable degree of certainty. Geo. A. Orrok's results have been used for the present purpose so far as possible.

The variables affecting heat transmission on the *steam side of the tube in an actual condenser* are complex and difficult of isolation; yet as an observed fact, their influence really dominates performance, since the coefficients of heat transfer still vary several hundred per cent after all variables affecting heat transfer on the water side have been allowed for.



F G. RELATION BETWEEN COEFFICIENT OF HEAT TRANSFER AND TEMPERATURE DEPRESSION

In Fig. 1 the coefficient of heat transmission for a number of surface condensers is plotted against difference between steam and condensate temperatures. Graph *a* refers to a 24,000 sq. ft. condenser loaded to 5.9 lb. per sq. ft.; graph *b* to an 18,000 sq. ft. condenser loaded to 7.5 lb. per sq. ft.; graph *c* to an 18,000 sq. ft. condenser loaded to 4.07 lb. per sq. ft.; graph *d* to an 18,000 sq. ft. condenser loaded to 8.09 lb. per sq. ft., and graph *e* to a 21,000 sq. ft. condenser loaded to 5.95 lb. per sq. ft. Graphs *a* and *d* coincide. In graph *f*, for a 25,000 sq. ft. base condenser, the coefficient rises to a value of 850 B.t.u. for a single set of observations. Graph *g* refers to five condensers of different sizes, loads and vacuums, two with wet vacuum pumps and the others with hydraulic air pumps. Graph *h* shows the relation for a vacuum evaporator (in this case the actual air-steam mixture was observed, not the condensate).

Fig. 2 shows similar graphs based on results obtained by Prof. J. A. Smith with experimental laboratory apparatus. The four lower curves show the relations existing between the

coefficient of heat transmission and the number of degrees which the temperature of the air-steam mixture is below the steam temperature corresponding to the total pressure. Calling the heat transfer at zero air 100 per cent, all the results for different steam temperatures can be combined in a single percentage of efficiency curve, as shown by B, Fig. 2.

The maximum heat transmission, obtained by Smith with pure steam is low as compared with that obtained by Orrok and others.

Graph B is replotted as the dotted graph *j* in Fig. 1 by assuming the maximum coefficient to be 1000 at a condensate temperature 3 deg. below steam temperature, in order to bring it into the region of the other graphs representing commercial condensers. Graph *j* is then seen to have the same trend as the others.

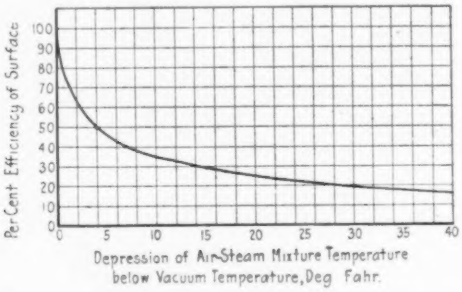


FIG. 3 EFFICIENCY OF SURFACE VS. TEMPERATURE DEPRESSION

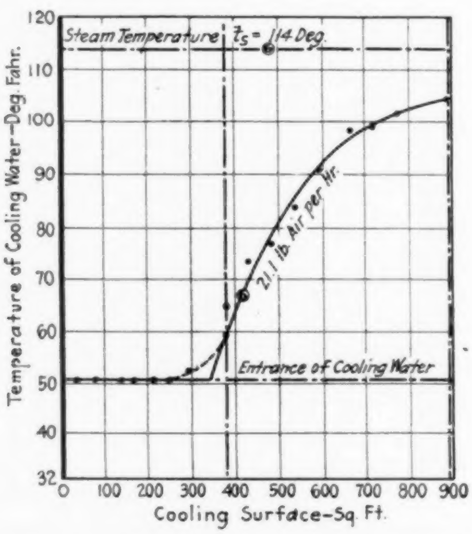


FIG. 4 RISE OF WATER TEMPERATURE IN PASSING THROUGH CONDENSER INDICATES ACTIVE AND INACTIVE ZONES

The graph of Fig. 3 was obtained by averaging the results represented in graphs *a, b, c, d, e, f, g,* and *h,* and expressing the heat transmission as a percentage of the maximum obtainable under the conditions of rate of heat transfer through the tubes and from tubes to water, prevailing in the condensers considered.

The performance of a condenser is usually dominated, to the exclusion of other factors, by the extent of the active and inactive zones of condensation. Thus tests show that the coefficient averaged for all the surface may *increase* as the water velocity *decreases.* The explanation is to be found in the lower vacuum and smaller specific volume of steam corresponding to the lower velocity, smaller quantity and higher final temperature of circulating water, under which conditions there is greater steam penetration and more surface is brought into action.

Other explanations of the variations in heat transmission coefficient have been founded principally on the variables affecting the water side of the tube or on the theory that a constant coefficient would be obtained by assuming the total heat transfer to vary as some fractional power of the instantaneous temperature difference instead of the first power.

We may assume for the present that the coefficient of heat transfer for a single tube immersed in steam depends on the water velocity (in an open tube or manner of agitation in other tubes), size of tube, material and cleanliness of tube and mean water temperature, but that all of these factors taken together do not explain the wide disparity of results obtained with actual condensers. We may also assume in the light of evidence that the total heat transfer is a function of the first power of the temperature difference and not of a fractional power as suggested by Loeb and Orrok.

Measurements of rise in temperature of circulating water in multiple pass condensers have shown that there are two

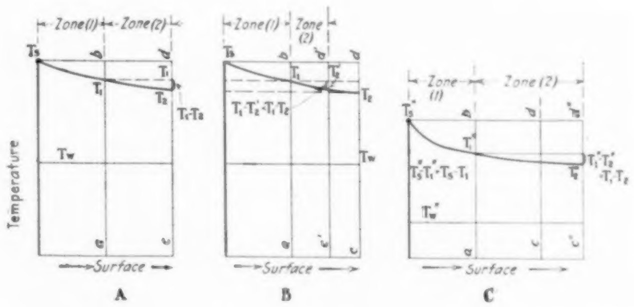


FIG. 5 VARIATION OF PROPORTION OF ACTIVE AND INACTIVE ZONES IN AN "ELASTIC" CONDENSER

COMBINED EFFECTS OF PRESSURE DROP AND AIR

fairly well defined zones in a surface condenser: one in which condensation takes place actively, the other wherein very little condensation takes place. Fig. 4 from a paper by Prof. Josse shows readings of water temperature and of heat absorbed in an actual condenser plotted against surface traversed. About 40 per cent of the surface is inactive.

Let us consider a condenser, Fig. 5A, in which steam condensation occurs up to line *a b* and air concentration during the flow over the remainder of the tube surface; i.e., nearly all the heat is transmitted to the water in that part of the surface preceding the line *a b*. The water temperature is assumed constant at T_w. In the first zone the temperature drop to T_1 is almost entirely due to the pressure drop required to overcome the pneumatic resistance offered by the condenser structure to the flow of a large volume of steam. From this region on, the temperature drop corresponds to the reduction in partial pressure of the water vapor, the drop in total pressure being negligible, due to the fact that the volume flowing in this zone of the condenser, where only 1 or 2 per cent of the steam remains, is very small. The partial pressure of the air at exit is represented by the difference of the vapor pressures corresponding to the temperatures T_1 and T_2, T_2 being the final air pump suction temperature.

Now assume that the air leakage is reduced, or the air pump capacity increased, so that the air withdrawal occurs at some lower partial air pressure represented by the smaller difference $T_1—T_2'$ (Fig. 5B). A part of the zone (2) may then be

dispensed with and, as the same initial steam temperature T_s is maintained with less surface, the average coefficient of heat transfer will figure out higher.

Again, assume the case in Fig. 5C, wherein the water temperature is reduced and a higher vacuum maintained. If all of zone (1) up to $a\ b$ is to remain active, the pressure drop expressed in head of steam must increase approximately in proportion to the square of the steam velocity and specific volume. Temperature T_1'', is therefore closer to the water temperature T_w'' than before. Furthermore, the difference between this temperature T_1'' and the air pump suction temperature T_2'' must increase in order to give the same partial air pressure with a lower total pressure. This is explained by Fig. 6. For a constant partial air pressure, which means constant air leakage with constant pump displacement, the temperature difference and the percentage of air richness must both increase rapidly as the vacuum increases. For these two reasons more surface will be required in zone (2) of Fig. 5C extending it to $c''-_2d''$ and the average coefficient of heat transfer will accordingly figure out lower. [The coefficient will also be further reduced because the average temperature of the steam is now lower through zone (1) on account of the greater pressure drop.]

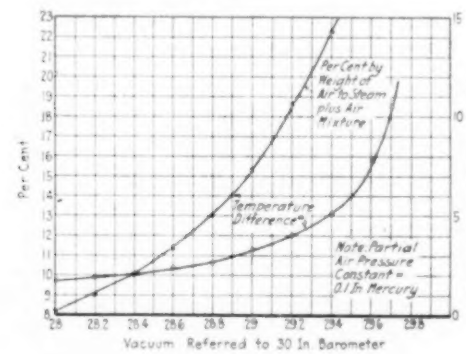


Fig. 6 Percentage Air in Mixture and Difference of Temperatures Corresponding to Total Pressure and that Actually Existing, for Constant Air Pressure of 1/10 in.

Many variables have to be taken into account to calculate the actual relative depths of these zones in a condenser. Among the independent variables which would need to be considered may be mentioned water velocity, initial water temperature, weight of water, tube diameter and cleanliness, arrangement of water passes, steam temperature, amount of air, air pump capacity, amount of surface and, perhaps most important of all, the arrangement or geometrical configuration of heat transmitting surface. However, we find that if the difference between vacuum temperature and air outlet temperature $T_s - T_2$ is increased by increasing pressure drop or by increasing the amount of air, there is a decrease in the average coefficient of transmission; and conversely if $T_s - T_2$ is decreased by decreasing pressure drop or decreasing the amount of air, there is an increase in the average coefficient. Empirical results showing the same relation have been given in Figs. 1, 2 and 3.

PRESSURE DROP

If the proportion of steam condensed per tube, the depth of penetration and the steam density were all constant, the loss of head through the first zone of the condenser would vary as the square of the velocity, or according to the well known relation for inelastic fluids $h = v^2/2g$. If the amount of steam condensed per tube and the steam density remained constant, but the penetration increased in proportion to the velocity of entrance, the pressure drop would vary as the cube of the entrance velocity.

Pressure drops actually observed usually fall between these limits. By dividing both the steam weight flowing and the pressure drop resulting by the mean specific weight of the steam, test readings can be expressed in terms of steam velocity and "head" of steam.

In Fig. 7 are plotted on logarithmic paper the heads and proportional velocities obtained in the experiments by Loeb on the Bureau feed water heater. The points agree very closely with a line of slope 2.5; that is, the head varies as $V^{2.5}$. The exponent of 2.5 can be explained on the basis that at increased loads the steam penetrates farther into the heater; it is like pumping water into a leaky distribution system. This is borne out by the quantities plotted in Fig. 8 for three condensers of large size. In these tests the increase in steam

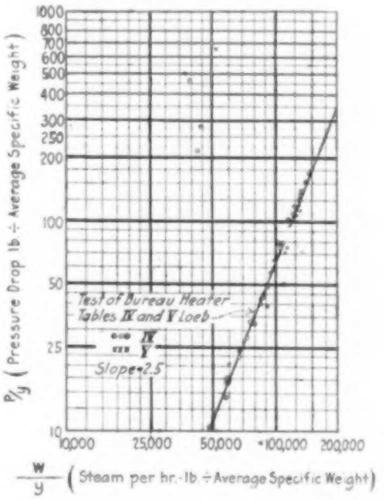


Fig. 7 Relation Between Pressure Drop and Steam Velocity

velocity (weight per hour divided by specific weight) is due entirely to increase in vacuum and specific volume, the weight flowing actually decreasing at the higher velocities.

In some cases the increase in steam velocity is accompanied by decrease in active zone, and then it would be expected that the head of steam would vary as a function of the velocity less than the square. This occurs, for example, when the load is decreased, but the vacuum greatly increased, as by the use of very cold water. The decrease in load is accompanied by greater air leakage and this taken together with the fact that the air-steam mixture must be richer at high vacuum, as has been shown by Fig. 5, causes an increase in the inactive zone and shortening of the active zone. At the same time the velocity of the steam increases due to the higher vacuum.

If the depth of the active condensing zone is assumed to remain constant, however, we can assume that the head lost varies at least as the square of the velocity. In estimating performance, this is a provisional basis of calculation; for, as will now be evident, to calculate the pressure drop it is necessary to know the depth of penetration, which in turn depends on the average heat transfer which is the final result sought by calculation.

CALCULATION OF SURFACE EFFICIENCY

Assume that the several characteristics of a surface condenser are known for 28.5 in. vacuum, under which conditions

the pressure drop through the condenser is 1/10 in. of mercury column and the air pump capacity and air inleakage are such that the partial pressure of the air is 0.124 in. of mercury, so that the depression of the air pump suction temperature is 5 deg. below the steam temperature, corresponding to an efficiency, from Fig. 3, of 45 per cent.

We wish now to know the conditions at 29 in. vacuum. We have seen from Fig. 5 that additional cooling surface is required in zone (2) in order to reduce terminal pressure, so that the weight of steam at the greater volume corresponding to the higher vacuum can penetrate to the same depth in zone (1), wherein, in other words, greater pressure drop will occur. In the actual condenser, the surface remains constant, so that there must be a re-adjustment of working conditions, zone (1) becoming smaller because of resistance to the flow of the greater steam volume, also because more surface is required in zone (2) for air concentration.

[We must bear in mind that zone (1) is not only affected by

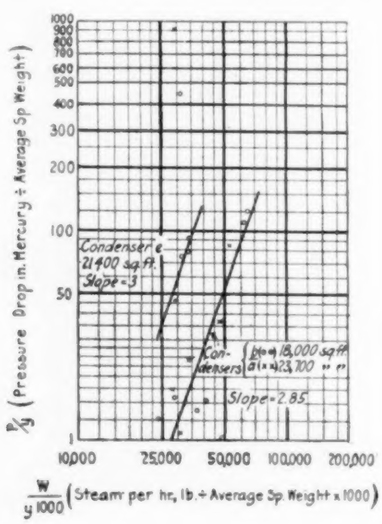


Fig. 8 Relation Between Pressure Drop and Steam Velocity

pneumatic conditions but by the performance of zone (2) and of the air pump. Thus if we slow down the air pump, zone (1) will be shortened with consequent decrease in vacuum.]

We can calculate the pressure drop for the assumed elastic condenser of Fig. 5, wherein zone (1) always remains the same. This, in connection with the depression due to air pressure, leads to a temperature difference $T_s—T_2$ and a corresponding surface efficiency, which we will apply to the actual condenser.

Thus the pressure drop at 28.5 in. of 0.1 in. becomes 0.148 in. for the larger volume at 29 in. vacuum and the total pressure at the air suction is (1—0.148)=0.852.

Modern air pumps, particularly the hydraulic types, running at constant speed, remove practically a constant volume of air, that is, have constant displacement or equivalent displacement under wide conditions of operation. Therefore with constant air inleakage the partial pressure of the air in the air-steam mixture withdrawn from the condenser must also be a constant, neglecting the slight effect of temperature on air volume.

The partial air pressure thus remains equal to 0.124 and the partial vapor pressure is 0.852—0.124=0.728 in. This pressure corresponds to a steam temperature of 69.5 deg., which is a depression of 9.5 deg. below the vacuum temperature, so that the efficiency of the condensing surface is now 36½ per cent, according to Fig. 3.

Similarly the depression for 29.2 in. vacuum is found to be 13.8 deg. and the efficiency 32 per cent, and so on for other vacuums, and a graph can be plotted as shown in Fig. 9, graph *A*.

Graphs *B*, *C* and *D* were obtained similarly, *B* being for a lower partial air pressure, due to less air leakage or a larger capacity pump, *C* for the same air conditions as *A*, but less pressure drop (as with better spacing of tubes), and *D* for both reduced air and less pressure drop.

Graph *B*: Reducing the air leakage (or increasing pump capacity) gives less temperature depression and hence raises the efficiency particularly at moderate vacuums.

Graph *C*: Reducing the pressure drop raises the high vacuum end of the efficiency curve and also extends it to higher vacuums. The efficiency of the surface at 29.4 in. vacuum is 36 per cent as against 25 per cent in graph *A*.

Graph *D*: Reducing both air leakage and pressure drop results in large increase in efficiency as shown by this graph.

ZONE CONDENSERS

We have been considering the conditions on the steam or steam-air side of the tubes, and the variations in the relative extension of the active zone of the condenser. The performance under any conditions will also be affected by the conductivity of the heating surface itself, dependent upon its

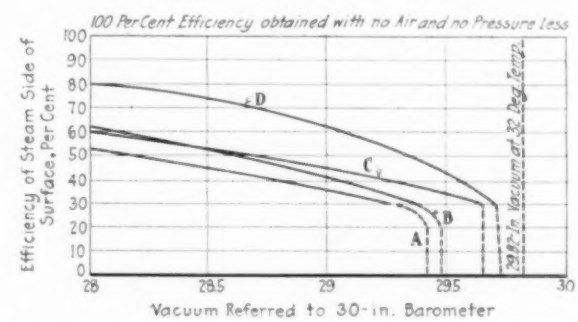


Fig. 9 Effect of Air and Pressure Loss on Efficiency

cleanliness and also upon the conductivity from the metal to the water within the tube. Fouling or scaling of condenser tubes will reduce heat transmission and can be corrected by cleaning only.

Assuming a clean condenser, the conductivity from the tube to the water becomes the controlling factor in the active zone, and therefore by increasing velocity, greater heat transmission and better vacuum can be obtained. In the inactive zone, however, any increase in velocity of the water is of little benefit. There is only a very small amount of heat being transmitted, so that the difference in temperature between the metal tube and the water is very small compared to the difference in temperature between the metal wall and the surrounding stagnant steam-air mixture. Hence any reduction in the already small temperature difference from metal to water gained by increase in water velocity has an imperceptible effect on the overall temperature difference between steam-air mixture and water and the corresponding rate of heat transfer, just as an increase in the size of the valve placed on the end of a long, small diameter pipe line, will not result in any appreciable increase in quantity of water discharged.

Thus whereas it is profitable to increase the water velocity through the tubes in the active zone of the condenser, any such increase is of no value commensurate with its cost in the inactive zone. A decrease of velocity in these tubes is even desirable, because by such decrease the power for pumping the circulating water can be decreased, or else for the same

power a higher velocity of water can be maintained through the tubes of the active zone where it will do some good. A large flow of water is not required for heat absorption in the inactive zone, as relatively little heat is transmitted here.

The application of this principle is shown by the sketches of Figs. 10, 11 and 12. In Fig. 10 a condenser is arranged with two passes, one containing three-fifths of the surface and the other two-fifths of the surface, the former being intended to comprise the active and the latter the inactive zone. All of the water is passed through the tubes of the active zone at high velocity. A part only of the water passes through the tubes of the inactive zone, the rest being short-circuited through the by-pass. If the velocity of the water through the inactive-zone tubes were one-fifth of that through the active-zone tubes, the head lost would only be 1/25 as great, with corresponding saving of power for pumping the circulating water. Thus, for the same circulating pump power as ordinarily required with a standard two-pass condenser, more water may be pumped and higher water velocity maintained condenser by proper arrangement of steam path and spacing of tubes, these being of great importance at very high vacuums.

The pressure drop through a condenser, expressed in terms of head of steam, varies as a function of the velocity of the steam, greater than the square if the increase in velocity is accompanied by an increase in average heat transmission coefficient and in depth of penetration, or smaller than the square if the increase in velocity is accompanied by a decrease in average heat transmission coefficient and in depth of penetration.

In purchasing high vacuum condensers, comparison should be made of the pneumatic resistance of the structures on the basis of velocity of flow at each row of tubes and the number of rows in series through which steam must flow. Attention should also be given to possibilities for the formation of air pockets out of the line of flow, considering both transverse and longitudinal sections.

The highest coefficients of heat transmission are obtainable

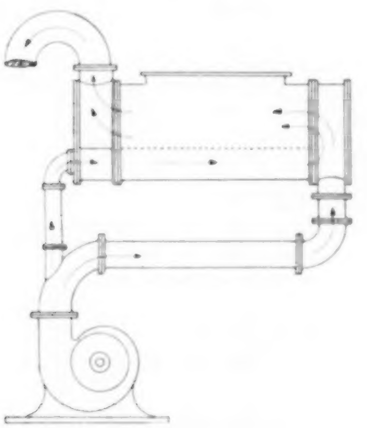


Fig. 10 Two-Pass Condenser with Active and Inactive Zones

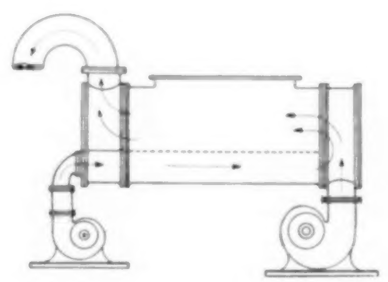


Fig. 11 Two-Pass Condenser with Active and Inactive Zones, Two Pumps

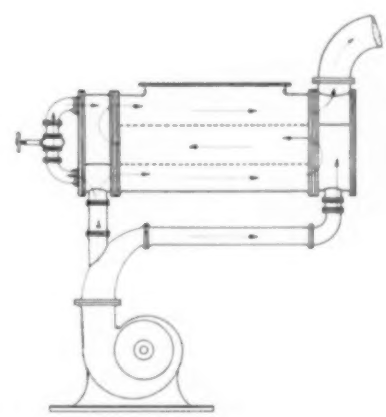


Fig. 12 Three-Pass Condenser with Three Zones of Different Activities

through the active tubes of the condenser. Fig. 11 shows how the same conditions are obtained using two circulating pumps.

In Fig. 12 is shown a three-pass condenser in which the velocity in the lower zone is small, in the middle zone fairly high, and in the upper zone the maximum. All of the water goes through the upper zone, but only part of the total through the other zones. By manipulation of the valve, the quantity of water going through the zones is varied to take care of different conditions of operation in summer and winter, and of load, air leakage, air pump capacity and vacuum. A three-pass zone condenser may also be built with, say, half the tubes in the bottom or first pass and the other half of the tubes divided between the two upper passes. The objection to this design is that the inactive zone is too large (one-half the total) and the water velocity still too high.

CONCLUSIONS

The lower average heat transfer coefficient obtained with cold circulating water is due principally to a greater proportion of the surface being inactive, which in turn is due to greater pressure drop incidental to the flow of a larger volume of steam and to the greater proportion of air to vapor existing in the mixture stagnating in the outlet zone of the condenser.

Better efficiency of surface at high vacuum can be obtained by preventing air inleakage, increasing pump capacity and decreasing the pressure drop or pneumatic resistance of the in condensers of moderate size in which the smaller depth of tube bank lessens the pneumatic resistance.

The depression of the air suction temperature below the inlet vacuum temperature is an index of the surface efficiency, on the steam side.

By analyzing the temperature depression in a given condenser into that due to pressure drop and that due to partial air pressure, it is possible to determine whether flow conditions or air conditions offer the greater possibility for improving efficiency and vacuum.

By means of accurate electrical resistance thermometers temperatures can be taken at a multitude of points on both steam and water sides of the surface of a condenser undergoing changes in operating conditions, which would enable one to isolate the factors influencing the extent of the active and inactive zones.

A high velocity of circulating water, or the equivalent increase in water film agitation by the use of cores or spirals, is desirable in the tubes of the active zone of a condenser; and this can be obtained, without additional power consumption in pumping the circulating water, by reducing the velocity of the water through the tubes of the inactive zone.

APPENDICES

In two appendices to the paper are discussed at some length the effects of viscosity, velocity and temperature difference on coefficient of heat transfer in high vacuum surface condensers.

HIGHER STEAM PRESSURES

BY ROBERT CRAMER, CHICAGO, ILL.

Member of the Society

THE history of the development of the steam engine presents a gradual but continuous and persistent rise of steam pressures, so that it seems natural that engineers should ask the question: "How far can steam pressures be practically and profitably increased?" Pleas for higher steam pressures have several times resulted from investigations of this subject; one of the most remarkable of these was Prof. R. H. Thurston's paper on the "Promise and Potency" of High-Pressure Steam, before the Society in December, 1896.

Since the science of thermodynamics has been recognized by engineers as a sure guide to improvement of heat engine economy, there has existed a tendency to increase the temperature range of the working fluid, that is, to increase the temperature at which the working medium absorbs heat and to lower the temperature at which it rejects heat. In steam engine practice this has led to the recognition of well defined limits: a maximum steam temperature of about 600 deg. fahr., above which lubrication of piston engines and maintenance of valve parts and packings is difficult, and a minimum condenser temperature of about 80 deg. fahr., corresponding to 29 in. of vacuum or $\frac{1}{2}$ lb. per sq. in. back pressure. This temperature is so near the usual cooling water temperature that a higher vacuum would require disproportionately large quantities of circulating water. The necessary size of the circulating pump and also the necessary increase in the size of the air pump render higher degrees of vacuum unprofitable.

In the best present day practice, except for slightly higher pressures in some few isolated cases, the maximum steam pressure is 200 lb. per. sq. in. abs., and the superheat is 200 deg. fahr. The corresponding temperature of evaporation is 382 deg. fahr. and the bulk of the heat is absorbed at a temperature 200 deg. fahr. below the maximum. It seems reasonable to expect that the approximation to the ideal Carnot cycle, and simultaneously the economy, would be improved by using higher pressure and less superheat, that is, by increasing the temperature at which the bulk of the heat is absorbed, without increasing the maximum temperature. Even a casual reference to steam tables and diagrams confirms this expectation and reveals the remarkable fact that the higher the steam pressure, the less the total heat in the steam if the final temperature be kept constant and correspondingly, the superheat is reduced with advancing pressures.

An examination of the Mollier total heat-entropy diagram shows that the amount of heat convertible into mechanical energy in adiabatic expansion to any given back pressure is considerably higher for high pressure and little superheat than for lower pressure and more superheat, if the maximum temperature of the steam is the same in both cases. We have thus two causes making for better thermal efficiency with increasing steam pressures at constant maximum temperature: the decreasing total heat of the steam and the increasing amount of that part of the heat which is convertible into mechanical energy in adiabatic expansion.

Fig. 1 illustrates the theoretical gains due to high steam pressures by means of the temperature-entropy diagram. This shows clearly how the relative amount of convertible heat increases with higher pressures, and the tabulations in Table 1 give exact numerical values.

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Tables 2 and 3 give the theoretical percentage of gain for certain comparisons, selected on account of their relation to conditions prevailing in present day practice. These tables show that, even in case of high vacuum in the condenser, the gains, while not overwhelmingly large, deserve careful consideration, and that in case of atmospheric exhaust, these gains are so large as to fully justify an endeavor to realize high steam pressures in practice. Theoretically, the efficiency of high pressure noncondensing engines should be as high as that of many condensing engines under present day conditions.

In all the comparisons the steam pressures are carried up to 1574 lb. per sq. in., which is the pressure at which saturated steam has a temperature of 600 deg. fahr. At the present time such high pressures should hardly be advocated, but the figures clearly indicate the gain which might be realized could designs of engines and turbines which are suitable for such steam pressures be successfully worked out.

TABLE 1 COMPARISON OF EFFICIENCY WITH DIFFERENT PRESSURES

Exhaust 29 In. Vacuum

Initial Condition of Steam			Heat Units in 1 Lb.		Ideal Efficiency	Ratio Compared with 1st Line	Cycle in Temp-entropy Diagram Fig. 1
Pressure Lb. per Sq. In. Abs.	Superheat Deg. Fahr.	Temperature of Steam, Deg. Fahr.	Total above Exhaust Temperature	Convertible in Adiabatic Expansion			
200	218	600	1267	417	0.3285	1.000	*a b c d e a*
600	113	600	1251	467	0.3730	1.135	*a f g h i* a_1
1574	0	600	1128	454	0.4025	1.226	*a k l m a*
Atmospheric Exhaust							
125	0	344	1010	157	0.1552	1.000	a_1 *n o p* a_1
600	113	600	1119	291	0.2600	1.675	a_1 *f g h q* a_1
1574	0	600	996	305	0.3062	1.972	a_1 *k l r* a_1

TABLE 2 RELATIVE GAIN IN THERMAL EFFICIENCY DUE TO INCREASING STEAM PRESSURE TO 600 LB. PER SQ. IN. ABS.

Final Condition of Steam	29 In. Vacuum		Atmospheric Exhaust	
Initial Condition of Steam	Constant Temperature 600 Deg. Fahr.	Constant Superheat 100 Deg.	Constant Temperature 600 Deg. Fahr.	Constant Superheat 100 deg.
As against 100 lb. initial pressure...	25 per cent	30 per cent	52 per cent	85 per cent
As against 200 lb. initial pressure...	13 per cent	$15\frac{1}{2}$ per cent	32 per cent	$37\frac{1}{2}$ per cent

The following considerations will show how far the benefits of high steam pressures may be realized under practical conditions, as far as our present knowledge and experience enable us to realize them.

The ideal Rankine cycle cannot be realized in practice. In steam turbines the expansion of the steam cannot be effected without friction losses which are converted into heat and to that extent make the expansion deviate from the adiabatic. It is also impossible to fully extract the mechanical energy which manifests itself in the velocity of the steam, the residual velocity representing a loss.

In piston engines of the double-flow type there are large losses due to initial condensation at the time of steam admission and to heat transfer between the steam and the cylinder walls. In the unaflow type of piston engine, properly designed, these losses can be almost entirely avoided. In this latter type of engine it is, however, impossible to carry the

expansion down to the condenser pressure, because if such were done the compression, which commences at the same point of the stroke where the expansion ends, would simply be an exact reversal of the expansion. Thus, the compression curve would retrace the expansion curve and no work would be done in the cylinder. In fact in this case no steam could enter the cylinder, because the clearance would contain as much steam of the same pressure and volume as that admitted for expansion.

These sources of loss, friction in the turbine, condensation in the double-flow piston engine and incomplete expansion in the unaflow engine, determine the practical limits of the possibility of realizing the Rankine cycle. In large steam turbines this approximation, or the Rankine cycle efficiency, has been carried to about 76 per cent, and it is a remarkable fact that an efficiency closely approximating this has been realized in unaflow engines, even in small sizes.

There is no reason why the same relative efficiency should not be realized with higher steam pressures. Such losses as are simply due to teimperature differences must be the same if the initial and final temperatures of the steam remain the same, because the temperature changes through which the steam passes in performing the cycle are of the same magnitude in both cases.

TABLE 3 RELATIVE GAIN IN THERMAL EFFICIENCY DUE TO INCREASING STEAM PRESSURE TO 1574 LB. PER SQ. IN. ABS.

Final Condition of Steam	29-in. Vacuum	Atmospheric Exhaust
As against 100 lb. initial pressure, 100 deg. fahr. superheat	41½ per cent	187 per cent
As against 200 lb. initial pressure, 218 deg. fahr. superheat	22½ per cent	105 per cent

In a steam turbine higher steam pressures will mean either higher velocities or more stages, both introducing higher friction losses. It is, however, to be expected that by careful design the percentage of these friction losses as compared with the total amount of energy available in adiabatic expansion can be kept the same as in present day practice. In unaflow engines it is quite possible to keep the percentage of loss due to incomplete expansion as low as the corresponding percentage in present-day practice.

The foregoing seems to justify the employment of higher steam pressures. Standard boiler designs, however, do not permit the production of steam of a pressure higher than about 200 lb. per sq. in. without sacrificing safety and without calling for an investment in the boiler plant high enough to offset the gain in economy caused by higher steam pressures.

The solution of the problem of boiler safety under high steam pressures demands two fundamental changes in boiler design:

a The boiler must be constructed entirely of tubes of relatively small diameter. All drums and vessels of large diameter, as well as all flat surfaces (even if stayed) must be abandoned.

b Expanded, beaded or riveted joints exposed to the action of the fire must be avoided. That part of the boiler which receives the heat of the furnace must be practically a one-piece structure.

It is important that in meeting these requirements the essential characteristic of water circulation in the boiler be retained in order to make possible a control of the steam pressure and of the water content of the boiler by simple means. Flash boilers, while permitting high steam pressures, are not desirable because they require complicated automatic regulating devices necessary on account of the interdependence of feed and fire control.

In considering boilers for high steam pressures, it must not be overlooked that the mass of water in the boiler is at a higher temperature than that in a low-pressure boiler. This difference amounts to approximately 100 deg. for 600 lb. pressure as compared with 200 lb. Even if the heating surface is made very large, or, in other words, the evaporation per square foot is kept very low, the stack gases will leave the high-pressure boiler at a temperature 100 deg. higher than the corresponding gases of the low-pressure boiler. The boiler efficiency, other things being equal, is correspondingly reduced.

It is, of course, possible to meet this difficulty by making the heating surface of high-pressure boilers larger in proportion to what is current practice in boilers working under pressures used today. It is also possible to increase the effectiveness of the heating surface by proper design. Boiler designers are realizing the possibilities in this direction, even with steam pressures not higher than 200 lb. This is demonstrated by the fact that modern boilers show an evaporation per square foot of heating surface twice as high as was customary only a few years ago, at the same time realizing a better efficiency than formerly.

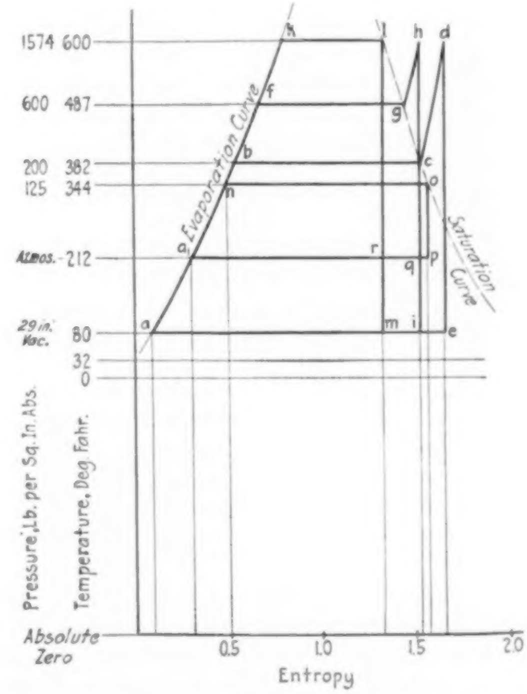

FIG. 1 TEMPERATURE-ENTROPY DIAGRAM FOR STEAM

It therefore seems reasonable that highly efficient high-pressure steam boilers can be made, even without resorting to special heat saving apparatus to offset the effect of the higher temperature of the water in the boiler. The possibilities of these extraneous heat saving devices should, however, not be overlooked. Even though the waste gases leaving the boiler have a temperature of 700 deg. fahr. or more, a properly installed economizer will reduce this temperature to any desired degree within the limits given by the temperature of the feed water. Even a very small economizer will save enough heat to offset the loss due to the higher temperature corresponding to higher pressure. In some instances, the waste gases might profitably be used to heat the air which supports combustion in the furnace.

The question of strength of constructional parts outside of the boiler to withstand high steam pressures is of great importance. In reciprocating engines this question can be answered from practice, because pressures far exceeding 600 lb. per sq. in. are used successfully in gas engines and Diesel engines, and therefore the design of cylinders for high steam pressures should not present any difficulties which have not already been overcome in other types of machines.

In steam turbines, especially in those of larger size, the casings of large diameter would need to have disproportionately heavy walls were they required to withstand pressures much higher than those employed today. The solution of the problem of adapting turbines to high pressures is found in the principle underlying most present designs of large steam turbine units. According to this principle, the pressure of the steam is greatly reduced in the first nozzle and the resulting high velocity is utilized in several rows of blades of the velocity stage type. Thus, it is possible to confine high pressures to the steam piping and to the "steam belt" carrying the steam to the first nozzles, but to have comparatively low pressure even in the first part of the casing. The lesser efficiency of the velocity staging is not so serious at the high-pressure end as it would be at the low-pressure end, because the loss manifests itself in a somewhat higher superheat of the steam entering the succeeding stages and is therefore partly recovered.

With high pressures, the difficulties with piping and fittings are greatly reduced on account of the reduced specific volume of the steam. Even if lower rates of flow than those customary in present practice are permitted in high-pressure steam lines (on account of the greater density of the steam), the fact that one pound of steam at 600 lb. pressure occupies approximately one-third of the space required by one pound at 200 lb. pressure reduces the required size of the piping and fittings to such an extent that both difficulties in design and cost for a given capacity are, if anything, less than for lower pressures.

In piston engines the question of cylinder lubrication is important. It is apparent that high steam pressures will permit neither slide nor Corliss valves. The advent of higher pressure will cause the poppet valve to come into its own in America, where it is now seldom used, in spite of the great success it has had in Europe for many years, lately the flexible seat type especially.

The largest part of the lubricating oil now used in piston engines is required for the steam distributing valves. That part required by the piston and piston rings is very small and the possibility of sufficient piston lubrication is not affected by higher initial steam pressures, because even in case of very high mean effective pressures in single-acting engines, where the piston serves as cross-head and therefore requires constant lubrication, the piston can be made long enough to keep the pressure per square inch within proper limits.

For a given output the cost of a unaflow engine suitable for high steam pressures should be less than that of double-flow engines, as soon as it can be manufactured under economical conditions of manufacture. Such an engine, if single-acting, has but one very simple organ of steam distribution and on account of its high mean effective pressure its weight per horsepower is low. Even in a single-acting engine of this type the mechanism is utilized twice as efficiently as in a four-stroke cycle Diesel engine.

Steam turbines for high steam pressures would probably cost a little more than those using lower pressures and giving the same power, on account of the extra stages required. This extra cost would be offset by a considerable saving in the required condenser cooling surface on account of the larger percentage of moisture in the steam entering the condenser and the reduced steam consumption due to better thermal efficiency. Table 4 will make this clear.

The question of stuffing boxes can be entirely eliminated in both turbines and piston engines—in turbines because high steam pressures need not be carried beyond the first nozzle, and in piston engines because the single-acting type of engine is from many points of view the logical design for high pressures. In such a piston engine the stem of the one valve can be provided with a "labyrinth" packing, as has been successfully done in practice.

TABLE 4 REDUCED STEAM CONSUMPTION DUE TO BETTER THERMAL EFFICIENCY

Initial Condition of Steam	200 lb. 600 Deg. Fahr.	600 lb. 600 Deg. Fahr.
Ideal efficiency with 29 in. vacuum	0.329	0.373
Percentage of steam in exhaust	0.814	0.749

Ratio of condenser cooling surface $= 0.329 \times 0.749 / 0.373 \times 0.814 = 0.812$. Thus, a saving of about 19 per cent of the condenser cooling surface might be expected.

In the design of power houses the question of the proper arrangement of the auxiliary apparatus, such as feed pumps, air and circulating pumps, fans and stokers, would have to be considered from the point of view of high steam pressures. In very large plants all auxiliaries are often driven by electric power, and the current for them is furnished by a separate power unit. Inasmuch as these "house service units" in modern power plants have capacities of 2000 kw. and over, it is a simple matter to operate them directly with high-pressure steam.

Where it is desired that the auxiliaries be driven entirely independent, it should be possible to drive them with high-pressure steam turbines if the size of the auxiliary unit warrants this, or by high-pressure unaflow engines for the smaller sizes. In this latter case, the objection might be raised that the exhaust of the unaflow engine would introduce a certain amount of lubricating oil into the condenser. This question can be met in different ways. If the unaflow engine is of the vertical single-acting type, the lubrication can be reduced to a very small amount, and could possibly be accomplished with graphite only, so that the amount of lubricant introduced into the condenser would be insignificant and harmless.

Another way of meeting this question would be the noncondensing operation of the unaflow engines, using the heat of their exhaust in a feed water heater. This manner of operation appears to be very attractive, because the economy of noncondensing unaflow engines, as compared with noncondensing engines of other types, is extremely high. Where clean feed water is readily available, the method would be readily applicable, or the unaflow auxiliary units might be connected to an independent small jet condenser.

It seems clear that if steam pressures are increased to, say 600 lb. per sq. in. without using temperatures higher than those employed in modern practice, the difficulties encountered by the designer are not formidable and are more easily met than in the case of some types of explosion engines which have been successfully designed. The result to be attained by adopting such high steam pressures appears to be fully worth the effort, because thermal efficiencies closely approaching those of explosion engines can be realized with simpler apparatus and consequently better overall economy, at the same time retaining all the great practical advantages which steam utilization has over any other method of producing power.

PROPORTIONING CHIMNEYS ON A GAS BASIS

BY A. L. MENZIN, PHILADELPHIA, PA.

Associate-Member of the Society

THE first half of this paper is devoted to the mathematical development of the data required for calculating chimneys on a gas basis, taking into account the increasing tendency to operate boilers at higher overloads, the attention being given to baffling as a factor in improving boiler performance, and the efforts to improve the efficiency of combustion, resulting in a reduction of the volume of gases to be removed.

In the second half the applications of the formulae and data are exemplified by the consideration of the following problem: What sizes of chimneys will be suitable for two 500 h.p. boilers for continuous operation at not over 150 per cent of rating? The temperature of the air will not exceed 80 deg. fahr., and the breeching will be about 50 ft. long and have two right angle turns.

The following symbols are used in the equations given:

A = area of a circular conduit, sq. ft.
d = diameter in ft. corresponding to A
H = effective height of chimney, ft.
l = equivalent length of breeching, ft.
P = barometric pressure, in. of mercury
P_b = draft loss through the boiler, in. of water
P_e = total effective draft required at the entrance to the chimney, in. of water.
P_f = draft required in the furnace, in. of water
P_r = total draft loss in the breeching due to friction, in. of water
P_v = draft required to increase velocity, in. of water
P_v' = draft loss caused by sudden enlargement of the gas passage, in. of water.
P_c = draft loss in the chimney, in. of water
p_c = draft loss in the chimney per 100 ft., in. of water
P_s = maximum draft produced by the chimney, in. of water
p_s = maximum draft produced by the chimney per 100 ft., in. of water
P_d = damper friction, in. of water
q = volume of gases, cu. ft. per sec. per boiler h.p.
Q = total volume of gases, cu. ft. per sec.
t_a = temperature of the air, deg. fahr.
t_c = temperature of the flue gases, deg. fahr.
v = velocity of gases, ft. per sec.
γ = density of gases, lb. per cu. ft.

In general

$$P_f + P_b = (P_s - P_c) - P_r - P_d$$

In applications to the design of chimneys, $P_d = O$, since the damper will be assumed to be wide open. Also since the maximum draft and the draft loss in the chimney are both proportional to its effective height, H, then $P_s - P_c$ may be replaced by

$$\frac{H}{100}\,(p_s - p_c)$$

and, in form for chimney calculations,

$$H = \frac{100\,P_e}{(p_s - p_c)}$$

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DETERMINING THE DRAFT REQUIRED AT THE BOILER DAMPER

This must be assumed from a knowledge of the equipment and conditions. Ordinarily, the draft required may be taken from characteristic curves, of which Fig. 1 is typical for boilers.

The draft required at the boiler damper is the sum of the draft assumed to be required in the furnace plus the assumed draft loss through the boiler.

The lower curve is based on observed draft losses during tests with coal fuel when the CO_2 in the gases was relatively high on correction of these losses to a standard of 13 per cent CO_2 and on the assumption that the draft loss varies as the square of the percentage of rating developed. This curve may be considered as applicable to boilers 15 tubes high without superheaters. The points circumscribed by circles are for a boiler 14 tubes high, but with a superheater over the first and second passes; the circumscribed crosses are for a boiler 13 tubes high also with superheater.

The upper curve was constructed from the lower by allowing for increased air, but at a decreasing rate for increasing overload. While it is not unusual for a boiler to develop its

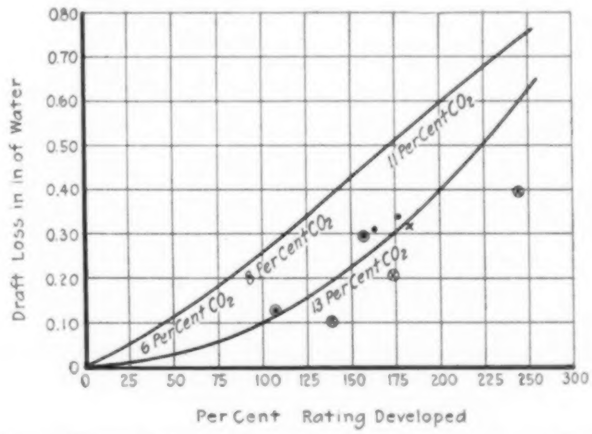

FIG. 1 DRAFT LOSS FROM FURNACE TO DAMPER OF A CROSS-BAFFLED THREE-PASS EDGE MOOR WATER TUBE BOILER WITH 18-FT. TUBES

For Efficient and Inefficient Firing

rated capacity with 8 per cent CO_2 in the escaping gases, it is hardly to be expected that a boiler should develop 175 per cent of rating with less than 11 per cent CO_2. Hence the variation in the percentages of CO_2 assumed.

In connection with the draft required in the furnace for natural draft and coal fuel, the following formula is useful:

$$C = \frac{(\text{h.p.}) \times 33480}{U\,E\,G}$$

where C is the maximum weight of coal to be burned in lb. per sq. ft. of grate surface per hr., (h.p.) is the maximum horsepower to be developed, U is the calorific value of the coal in B.t.u. per lb., E is the efficiency of the combined generator and G is the grate surface in sq. ft.

For the present problem, P_f will be taken as 0.25 in. and $P_b = 0.45$ in. The draft required at the boiler damper is then $0.25 + 0.45 = 0.70$ in.

DETERMINING THE QUANTITY OF GAS TO BE TRANSMITTED

Table 1 is for the general case. It is assumed that the true combustibles are practically total carbon, available hydrogen $(H - O/8)$ and sulphur. Sulphur occurs in small quantities, requires little air for combustion and has a low heat value; it may therefore be neglected in approximate calculations.

Hence coal may be considered as composed of carbon and available hydrogen.

The weight of gas per horsepower is approximately

$$W = \frac{33480w}{10{,}000\ (E + 0.02)}$$

where W is the weight of gas in lb. per hr. per boiler h.p., w is the weight of gas per 10,000 B.t.u., and E is the combined efficiency of the steam generator. w may be taken from Table 1. The quantity 0.02 added to E is an average allowance for carbon in the ash.

Example: At 9 per cent CO_2, $w = 15.7$. Let $E = 0.66$.

$$W = \frac{33480 \times 15.7}{10{,}000(0.66 + 0.02)} = 77.3 \text{ lb.}$$

The weight per sec. is $W/3600$, and γ by the formula $\gamma = \dfrac{41.3P}{30(t_c + 459.6)}$ where γ is the weight in lb. of 1 cu. ft. of gases, t_c is the temperature of the gases in deg. fahr., P is barometric pressure, in inches of mercury, is $(41.3P) \div \{30(t_c + 459.6)\}$. Hence the formula for the volume per sec. is

$$q = \frac{30W(t_c + 459.6)}{41.3P \times 3600} = \frac{6.73W(t_c + 459.6)}{1{,}000{,}000} \times \frac{30}{P}$$

where q is the volume of gas in cu. ft. per sec. per boiler h.p.

In ordinary problems, Table 2 may be used instead of calculating q by the formula above. A variation of 100 deg. either side of the standard of 540 deg. fahr. alters the volume by 10 per cent.

Returning to the problem, the volume of gases to be removed by the chimney may now be calculated. The maximum horsepower to be developed is $2 \times 500 \times 1.5 = 1500$ h.p.

$q = 0.52$ from Table 2 for 9 per cent CO_2 and 66 per cent efficiency. Then the total volume of gases per sec. is

$$Q = 1500 \times 0.52 = 780 \text{ cu. ft.}$$

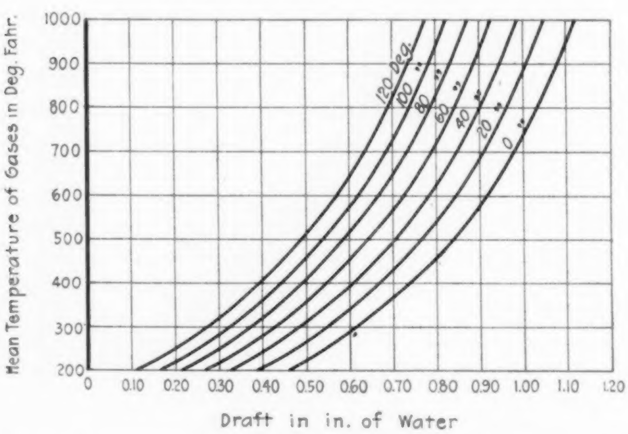

Fig. 2 Maximum Draft at Sea Level per 100 Ft. of Chimney Height Corresponding to the Air Temperatures Noted on the Curves

For any other height, H in ft. multiply by 0.01 H.
For any other altitude, multiply by the corresponding factor of correction from Fig. 3.

TABLE 1 WEIGHT OF GASES AND PERCENTAGE OF HEAT REJECTED TO THE CHIMNEY FOR DIFFERENT PERCENTAGES OF CO_2 WHEN CO = 0

Per Cent CO_2 in the Dry Gases by Volume	18.7	18.0	17.0	16.0	15.0	14.0	13.0	12.0
Excess air in per cent of the theoretical minimum	0	4	10	17	24	33	43	54
Weight of gases per 10,000 B.t.u. in the coal, lb.	7.8	8.1	8.6	9.1	9.6	10.3	11.0	11.9
Chimney loss per 100 deg. fahr. in per cent of the calorific value of the coal	1.85	1.92	2.04	2.16	2.28	2.44	2.61	2.82
Chimney loss per 500 deg. fahr.	9.25	9.60	10.20	10.80	11.40	12.20	13.05	14.10

Per cent CO_2 in the Dry Gases by Volume	11.0	10.0	9.0	8.0	7.0	6.0	5.0
Excess air in per cent of the theoretical minimum	68	85	105	130	162	206	267
Weight of gases per 10,000 B.t.u. in the coal, lb.	12.9	14.2	15.7	17.6	20.0	23.3	27.8
Chimney loss per 100 deg. fahr. in per cent of the calorific value of the coal	3.06	3.37	3.72	4.17	4.74	5.52	6.59
Chimney loss per 500 deg. fahr.	15.30	16.85	18.60	20.85	23.70	27.60	32.95

DETERMINING THE MAXIMUM DRAFT PRODUCED BY THE CHIMNEY

The general formula is

$$P_s = 0.255PH\left(\frac{1}{t_a + 459.6} - \frac{1.04}{t_c + 459.6}\right)$$

Values of P_s per 100 ft. of height and the factor of correction for different altitudes and pressures are given graphically in Figs. 2 and 3.

In the problem $t_a = 80$ deg. fahr. Let $t_c = 500$ deg. fahr. Then from Fig. 2 $p_s = 0.59$ in. If the altitude is 5900 ft. above sea level, then the factor of correction from Fig. 3 is 0.8. Hence $p_s = 0.8 \times 0.59 = 0.47$ in.

TABLE 2 WEIGHT AND VOLUME OF GAS PER BOILER HORSEPOWER AT SEA LEVEL

Assumed CO_2 per cent of dry gases by volume	8	8	9	10	12	12	14	14
Assumed combined efficiency of boiler, furnace and grate	63	66	66	68	70	75	68	78
Weight of gases in lb. per hr. per boiler h.p.	91	87	77	68	55	52	40	43
Volume of gases in cu. cu. ft. per sec. per boiler h.p. for a temperature of 540 deg. fahr.	.61	.58	.52	.46	.37	.35	.33	.29
Suggested corresponding percentage of rated capacity of boiler to be used for proportioning chimneys	100	125	150	..	200	..	250	..

DETERMINING THE DRAFT LOSS IN THE CHIMNEY

The formula for this is

$$P_r = 0.008\frac{l}{d}\left(\frac{v^2}{t_c + 459.6}\right)$$

By means of this formula, the values shown graphically in Fig. 4 were obtained.

A variation of 100 deg. either side of the assumed standard of 540 deg. fahr. and a variation of 3 in. in barometric pressure, if uncorrected for, would each introduce an error of 10 per cent in the draft loss. Since the draft loss is usually small, it would seem that ordinarily only variations beyond these limits need be considered.

Before the curves in Fig. 4 may be used, it is necessary to assume a velocity. If v is assumed then A follows from the formula $A = Q/v$. For a first approximation, the velocity may be selected from Table 3.

In the present problem, the volume of gas to be removed is 780 cu. ft. per sec. Assuming a velocity of 25 ft. per sec., $A = 780/25 = 31.2$. The friction loss per 100 ft., by visual interpolation on Fig. 4, is $p_c = 0.08$ in. This is for a circular chimney at sea level.

TABLE 3 ASSUMED ECONOMICAL VELOCITIES FOR A FIRST APPROXIMATION

Volume of gas to be removed in cu. ft. per sec.	10	50	150	500	1200	2500	5000	8000
Economical velocity in ft. per sec.	10	15	20	25	30	35	40	45

For a square chimney of side equal to diameter of the circular chimney $p_c = 0.62 \times 0.08 = 0.05$ in. For a circular chimney and barometric pressure 24 in. of mercury, $p_c = (30/24)\ 0.08 = 0.10$ in. For a circular chimney at sea level but gas temperature equal to 650 deg., $p_c = \{(640 + 460) \div 1000\}\ 0.08 = 0.09$ in. For a square chimney, barometer at 24 in. and gases at 640 deg. fahr.,

$$p_c = 0.62 \frac{30}{24} \frac{640 + 460}{1000} 0.08 = 0.07 \text{ in.}$$

DETERMINING THE FRICTION LOSS IN THE BREECHING

The customary assumption is that one sharp right angle turn has the same friction as 50 ft. of length. In the problem the breeching is to be 50 ft. long and to have two turns. Hence $l = (2 \times 50) + 50 = 150$ ft. Assuming the breeching will be square, with side equal to the diameter of the circular chimney, then $P_r = 1.5 \times 0.05 = 0.08$ in. The quantity 0.05 is the loss per 100 ft. as computed above. For a circular breeching of the same size as the chimney $P_r = 1.5 \times 0.08 = 0.12$ in. This does not indicate that the total loss in the square breeching will be less than that in the circular one because of the draft losses due to changes of velocity, as discussed in the following section.

DRAFT REQUIRED TO INCREASE VELOCITY

The formula is

$$P_v = 0.123 \frac{P(v_2^2 - v_1^2)}{30(t_c + 459.6)}$$

where v_1 is the initial velocity of the gases and v_2 is the final velocity.

The draft required to accelerate gases at sea level from zero velocity to velocities of 10, 20, 30 and 40 ft. per sec. for a temperature of 540 deg. fahr. is 0.012 in., 0.049 in., 0.111 in. and 0.197 in. respectively. The magnitude of this loss at the higher velocities explains the regulating effect produced by manipulating the damper.

The ratio of the area of a square to that of an inscribed circle is 1/0.7854. The velocity in the former will therefore be 0.7854 times the velocity in the latter. Table 4 shows the draft loss due to a velocity change based on this ratio for the case when gases pass from a square breeching into a circular chimney.

TABLE 4 DRAFT REQUIRED TO ACCELERATE GASES AT 540 DEG. FAHR., BAROMETER AT 30 IN.

Change of velocity in ft. per sec.	11.8 to 15	15.7 to 20	19.6 to 25	23.6 to 30	27.5 to 35	31.4 to 40	35.3 to 45	39.3 to 50
Draft required in in. of water	0.011	0.019	0.030	0.042	0.058	0.075	0.096	0.118

Except at the highest velocities, this draft is small enough to be neglected in the problem of calculating sizes of chimney; but as regards the design of the breeching this additional loss, for short breechings, may make the smaller circular breeching more desirable than the larger square breeching from an operating as well as a cost standpoint provided the gases leave the boilers at about the ultimate velocity.

Since the loss due to the velocity change will almost compensate for the decreased friction when the square breeching is used, if it is not long, then the friction loss per 100 ft. of breeching may be taken the same as in the circular chimney, whether the breeching will be square or circular.

LOSS OF DRAFT DUE TO SUDDEN ENLARGEMENT OF THE GAS PASSAGE

As stated in text books, eddies are set up when the velocity is decreased as a result of a sudden enlargement of the area. This is accompanied by a loss of pressure.

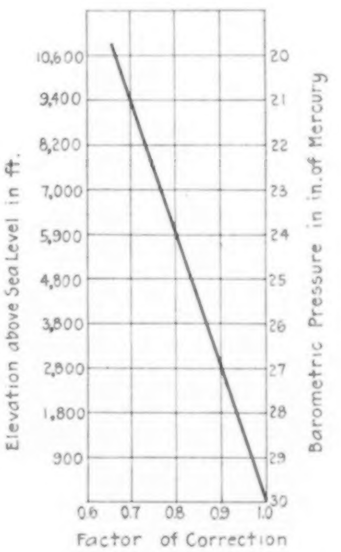

FIG. 3 FACTORS OF CORRECTION APPLICABLE TO FIG. 2

The formula is

$$P_v' = 0.123 \frac{P(v_1 - v_2)^2}{30(t_c + 459.6)}$$

For a change of velocity from 30 to 10 ft. per sec., at sea level and temperature equal to 540 deg. fahr. this loss is 0.049 in. Where there are several sudden enlargements in a long flue, the aggregate loss may be considerable. Hence gradual changes of cross section are preferable where there is something to be gained by enlarging the breeching.

DETERMINING THE VALUE OF d IN INCHES

d is the diameter of a circular chimney or breeching, or the length of one side of a square chimney or breeching. The curves in Fig. 4 are based on circular conduits, hence d is always the diameter corresponding to the area A. Obviously, a quick way to deterimne d is to divide the area A by 0.7854 on the upper scale of a slide rule and read d in in. opposite 12 on the lower scale.

PRACTICAL METHOD FOR CALCULATING CHIMNEYS

Solutions of chimney problems are very simple if carried out in the following form:

Equipment and Location. Two 500 h.p. boilers to be oper-

ated up to 150 per cent of rating. Breeching to have two right angle turns and to be about 50 ft. long. Chimney to be circular. Plant to be at about sea level.

Assumptions. $t_a = 80$ deg. fahr., $t_c = 500$ deg. fahr., $q =$ 0.52 cu. ft. (from Table 2), $P_f = 0.25$ in., $P_b = 0.45$ in., $P_f + P_b = 0.70$ in.

Calculations. Maximum h.p. $= 2 \times 500 \times 1.5 = 1500$.

$Q = 1500 \times 0.52 = 780$ cu. ft. Assume $v = 25$ ft. (from Table 3).

$A = Q/v = 780 \div 25 = 31.2$ sq. ft.

p_c from A and v on Fig. 4 $= 0.08$ in.

$l = (2 \times 50) + 50 = 150$ ft. $P_r = 1.5\ p_c = 1.5 \times 0.08 =$ 0.12 in.

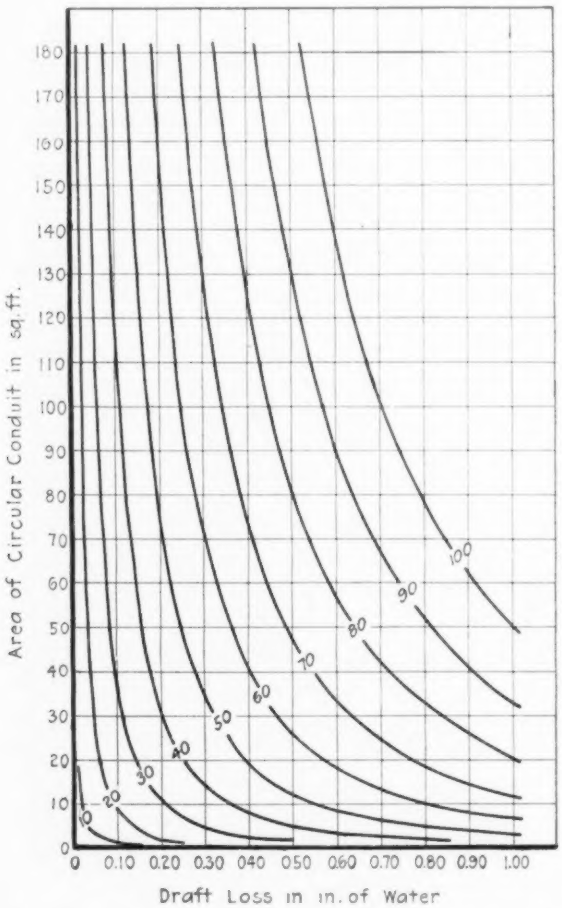

FIG. 4 DRAFT LOSS PER 100 FT. OF A CIRCULAR BRICK-LINED CONDUIT CORRESPONDING TO THE VELOCITIES IN FT. PER SEC. NOTED ON THE CURVES. FOR BAROMETER AT 30-IN. MERCURY, AND GASES AT 540 DEG. FAHR.

For any other height or length H in ft., multiply by 0.01 H
For a square conduit of side equal to the diameter of a circular conduit, multiply by 0.62
For any other barometric pressure P in in. of mercury, multiply by $30/P$
For any other gas temperature t in deg. fahr. multiply by $0.001\ (t + 460)$

$P_e = (P_f + P_b) + P_r + P_v + P_v' = 0.70 + 0.12 + 0 =$ 0.82 in.

$p_s = 0.59$ in. from Fig. 3. $p_s - p_c = 0.59 - 0.08 = 0.51$ in.

$$H = \frac{100 P_e}{p_s - p_c}$$

$$= \frac{100 \times 0.82}{0.51} = 161 \text{ ft.}$$

By writing the above calculations in the following tabular form (Case 1*a*) and assuming other velocities then other sizes may be obtained quickly.

The value of P_v in Case 1*d* is based on the assumption that the gases leave the boiler at a velocity of 20 ft. per sec. In the other cases P_v was assumed to be negligible.

The best size of chimney will depend, of course, on relative cost, local and other conditions.

To illustrate further, assume that the plant will be at an elevation of 5900 ft. above sea level and that the chimney will be square. Then $P = 24$ in. The maximum draft, p_s', will be 0.8 p_s and the friction loss in the breeching and chimney will be $0.62 \times 30/24$ $p_c' = 0.78\ p_c$ where p_c is the loss at sea level. Hence

$$p_s' = 0.8 \times 0.59 = 0.47 \text{ in.} \quad P_r = 1.5\ p_c'$$

Case	v	A	p_c	P_r	P_v	P_e	$p_s - p_c$	H	d
1*a*	25	31.2	0.08	0.12	0.0	0.82	0.51	161 ft.	76 in.
1*b*	20	39.0	0.04	0.06	0.0	0.76	0.55	138 ft.	85 in.
1*c*	30	26.0	0.12	0.18	0.0	0.88	0.47	187 ft.	69 in.
1*d*	40	19.5	0.26	0.39	0.15	1.24	0.33	376 ft.	60 in.

Case	v	A	p_c	p_c'	P_r	P_v	P_e	$p_s' - p_c'$	H	d
2*a*	25	31.2	0.08	0.06	0.09	0	0.79	0.41	193 ft.	76 in.
2*b*	20	39.0	0.04	0.03	0.04	0	0.74	0.44	16 ft.	85 in.
2*c*	1	52.0	0.02	0.02	0.03	0	0.73	0.45	162 ft	97 in.

Table 5 illustrates how the capacity of a chimney is affected by a variation of one or more of the governing conditions. The altered conditions are in italics. Since the quantity of gas per sec. per h.p. is dependent on both temperature of gases and combined efficiency, its value has been altered accordingly when these are involved.

TABLE 5 VARIABLE CAPACITY OF A CIRCULAR CHIMNEY 76 IN IN DIAMETER AND 160 FT. HIGH

Case	Temperature of Air, Deg. Fahr.	Temperature of Gases, Deg. Fahr.	Barometer, In.	Draft in Furnace, In.	Draft Loss in Boiler, In.	Draft Loss in Breeching, In.	Gas per Sec. per h.p. Cu. ft.	Capacity of the Chimney B.h.p
1*a*	80	500	30	0.25	0.45	0.12	0.52	1500
3	*100*	500	30	0.25	0.45	0.12	0.52	900
4	*20*	00	30	0.25	0.45	0.12	0.52	2700
5	80	*900*	30	0.25	0.45	0.12	*0.90*	2000
6	80	500	30	0.25	0.45	*0*	0.52	100
7	80	500	*27*	0.25	0.45	0.12	0.52	750
8	80	500	30	*0.20*	*0.22*	0.12	*0.35*	3900
9	80	500	30	*0.10*	*0.22*	0.12	*0.35*	4400
10	80	*600*	30	*0.10*	*0.60*	*0*	*0.33*	4200

Cases 1*a*, 3, 4, 6 and 7 are for a boiler in good condition but inefficiently fired. Cases 1*a*, 3, 4 and 7 are for different atmospheric conditions; Case 5 is representative of a boiler with baffles and heating surface in need of attention; Case 6 is for a chimney set directly over the boiler; Case 8 would apply to a natural draft installation efficiently operated; Case 9 is for an oil burning or forced draft installation efficiently operated; and Case 10 is for efficient operation at about 250 per cent of rating with forced draft and chimney set directly over the boiler.

UNIQUE HYDRAULIC POWER PLANT AT THE HENRY FORD FARMS

BY MARK A. REPLOGLE, AKRON, OHIO

Member of the Society

The hydraulic power plant at the Henry Ford Farms, Dearborn, Mich., contains two turbines designed to develop 85 h.p. each at 110 r.p.m. under 8-ft. head, together with electric generators. The plant supplies current for light, heat and power for Mr. Ford's residence, for the village pumping station, and for the miscellaneous requirements of the farms. It was built to operate under somewhat unusual conditions of head and contains features which the author believes to be novel and unique.

The plant is located on the River Rouge, near its junction with the Detroit River, which latter varies considerably with the levels of the Great Lakes. The Rouge River is subject to the widest extremes in flow. At the point of location of the plant is a dam over which the normal run-off is 100 sec-ft. There are short intervals, however, when the run-off is so great that it fills the valley with water so that no sign of the dam is apparent: at these times the head over the dam is completely destroyed, but the condition lasts only a few hours until the high water wave has passed. There are longer periods when the level is affected by the Great Lake conditions causing back water in the tail race and consequent lowering of the head for days at a time. Also, there may be weeks of surplus flow at semi-high head. In fact, the conditions may be summarized as

a Low water with normal head
b Low water with head lowered by Great Lake conditions
c Normal flow under variable heads
d High water with approximately half normal head, which is also variable and dependent upon Great Lake conditions
e Very high water, but with head almost destroyed

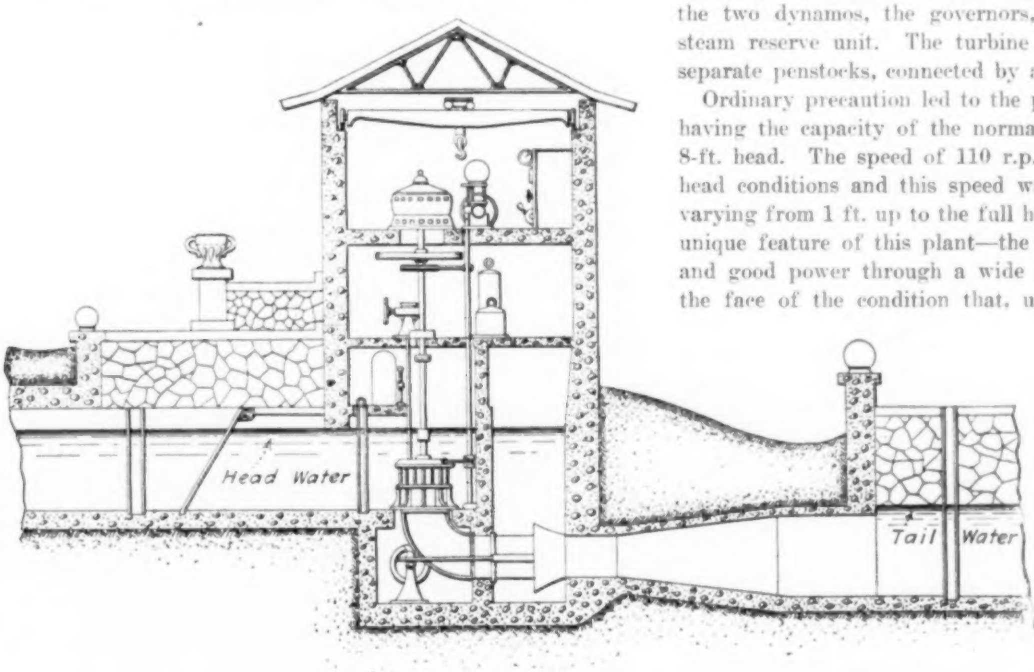

Fig. 1 Cross Section of Power House at the Henry Ford Farms

High water, with head varying from 2 to 5 ft., may persist for weeks at a time, so that provision to meet this condition was necessary. The condition of very high water but practically no head only obtains for a few hours at a time, and no adequate provision can be made for it, except the steam reserve.

The power house, an adjunct to Mr. Ford's private laboratory, is a concrete structure. The foundation consists of a monolith of reinforced concrete. Conditions made it necessary to floor the head race, power house site and tail race with concrete for several feet in thickness. The head race, 31 ft. wide and 10 ft. deep, was completely arched over for approximately 150 ft., and the tail race was similarly arched, both for architectural reasons.

The power house, Fig. 1, is a 3-story building, the lower floor containing the two turbines, the middle containing the auxiliary apparatus for controlling the turbines, and the upper the two dynamos, the governors, the switchboard and one steam reserve unit. The turbine floor is divided into three separate penstocks, connected by an overhead gallery.

Ordinary precaution led to the provision of two units, each having the capacity of the normal flow of the stream under 8-ft. head. The speed of 110 r.p.m. was established for full head conditions and this speed was maintained at all heads, varying from 1 ft. up to the full head of 8 ft. Herein lies the unique feature of this plant—the maintenance of full speeds and good power through a wide range of low heads and in the face of the condition that, under ordinary settings, the turbines employed require slightly over 4 ft. head to bring them to maximum speed at full gate and no load conditions.

The turbines are of the vertical type, designed, as stated, to develop 85 h.p. each on the turbine shaft when operating under 8 ft. head at 110 r.p.m. They have wicket gates, operated by draw rods from a gate shaft reaching directly to the governor arm. The turbine chambers are scroll-shaped, arranged for their respective right and left hand turbines. The weight of the runners is sustained by roller bearings on top of the generators. All under water bearings are of bronze.

The two turbo-generators are of the vertical type, 55 kw. each, at 250 volts. They are direct current machines and have ample overload capacity. Each is self-contained, having a roller bearing on top which supports all the rotating parts, including the balance wheels and turbines. A third steam engine generator is provided. This is horizontal, and is of 35 kw. capacity at 250 volts.

The governors which are direct connected and vertically driven are of the open system, oil-pressure type. Full apparatus is provided in the top floor of the power house for recording test conditions.

The three penstocks on the lowest floor can be closed by folding head gates, manipulated by the overhead crane. Of these penstocks, the middle one is a common feeder for the others, each of which contains what has been termed a "turbine discharge accelerator." These accelerators are a form of

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draft tube, into which each turbine discharges and into which, also, water from the head race is discharged through a feeder. The head race water accentuates the turbine flow through the draft tube, having the same effect as an added head of head water.

The purpose of the discharge accelerators is to transfer energy from surplus water (otherwise running over the dam or wasting) to the turbines, augmenting their power under subnormal heads after they have reached their otherwise full power at those heads. In other words, their effort is to boost the power of the turbines, working under low head conditions, beyond that which the conditions would seem to warrant.

The principle of the accelerator may be followed by reference to Fig. 2. In this figure is also shown a common siphon

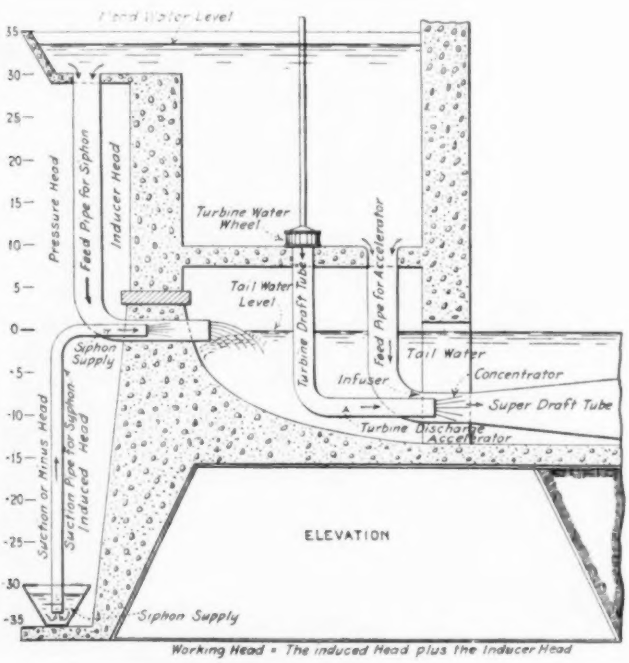

FIG. 2 COMPARISON OF SIPHON AND ACCELERATOR

for purposes of comparison. In the case of the siphon, the induced or suction head cannot be greater than the inducer, or pressure head. With the accelerator, the induced head may be greater than the inducer head. The accelerator is not an ejector.

The effect of the accelerator on the turbine is to partially remove the pressure at the discharge end without changing the pressure at the intake end. Under ordinary conditions, the pressure on both the head and tail water is 14.7 lb. per sq. in. alike. If the turbine were to discharge into tail water the pressure on which was, say, only 10 lb. per sq. in., the result would be the equivalent of adding slightly over 10 ft. head to the turbine, and as far as practical results were concerned, the turbine would now develop energy corresponding to the increased head. This is the effect of the discharge accelerator, which may therefore be likened in principle to a condenser of a steam engine.

Each accelerator consists of a super draft tube, a concentrator, and an infuser as shown in Fig. 3. The infuser is provided with a gate, by means of which the amount of accelerator water may be varied at will, or shut off entirely, in the latter case leaving only the turbine discharging into the super draft tube.

The area of cross section of the concentrator is less than that of the turbine draft tube. The effect of this narrowed section on the turbine's discharge during its ordinary operation was in doubt during the construction period, but when the installation was completed tests showed that the effect was negligible.

A series of tests were made on the accelerator of one unit on March 18, 1915, and the results are plotted in Fig. 4. In this figure, the scale of turbine horsepower is given on the left, kilowatts on the right and turbine gate opening in tenths below. A normal speed of 110 r.p.m. was maintained throughout the tests. The energy was absorbed by a water rheostat, and the power was measured by the switchboard instruments, which are new, therefore substantially correct.

The purpose of Series I was to show the maximum power of the turbine when the accelerator gates were closed. The curve shows approximately 90 turbine h.p. at between 9/10 and full gate, but the head was slightly over 8 ft.

Series II shows readings made at the same turbine gate openings, but the accelerator gate was open 20 per cent of its range throughout the series. Although the actual head is lowered, there is an actual increase in power.

Series III was made with the accelerator gate open about 40 per cent of its travel. This resulted in a still further increase of power.

Series IV was made with the accelerator gate open about 60 per cent of its travel. Throughout this series, the accelerator was sucking some air, but the power increased.

Series V was made with the accelerator gate open about 80 per cent of its travel. The accelerator sucked air violently during these last readings, but the power increased even though the head was less than 7 ft.

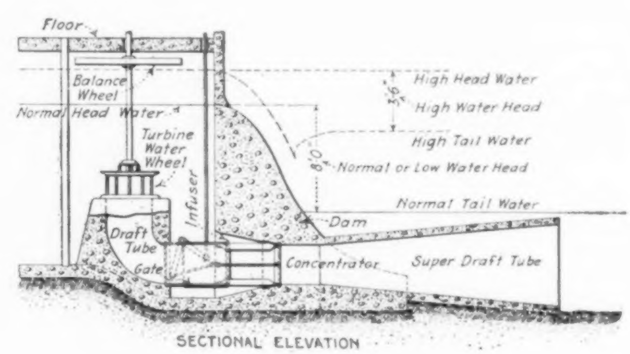

FIG. 3 85-H.P. TURBINE AND DISCHARGE ACCELERATOR

The excessive taking in of air prevented the further opening of the accelerator gate. Therefore its limit of action is unknown.

The curve in Series V shows 116 turbine h.p. at 6.94 ft. head. This curve, reduced by the well known formula, to an 8-ft. head shows that 143.5 h.p. can be obtained by the use of the accelerator from an 8-ft. head in connection with the identical turbine that had been guaranteed to develop 85 h.p. under 8-ft. head.

No attempt was made to measure the accelerator water used, as this test was made solely to demonstrate that a turbine can use waste water that would be detrimental to the power effects of the turbine if the accelerator were not used. The matter of measuring the water is a part of proposed further development, which will be continued until all the limitations are discovered.

The possibilities and limitations of the accelerator have not yet been fully determined, although several years of experi-

mentation have been spent in its development. In its operation, there seems to be some new and definite law, which has not yet been formulated. So far, indications are that low heads may be boosted as much as from 100 to 500 per cent, depending on the conditions. The extreme limit appears to be the atmospheric head.

The present instance is believed to be the first practical demonstration of the decided advantage to be secured by the application of the turbine discharge accelerator, and the design of the device is believed to be original.

There seems to be every reason to believe that full turbine power from a water turbine can be obtained from all the water used (when based on the actual or working head) even though only a portion of the water passes through the turbine proper. A water power equipped with an accelerator can be speeded for full head at low water condition, and the same

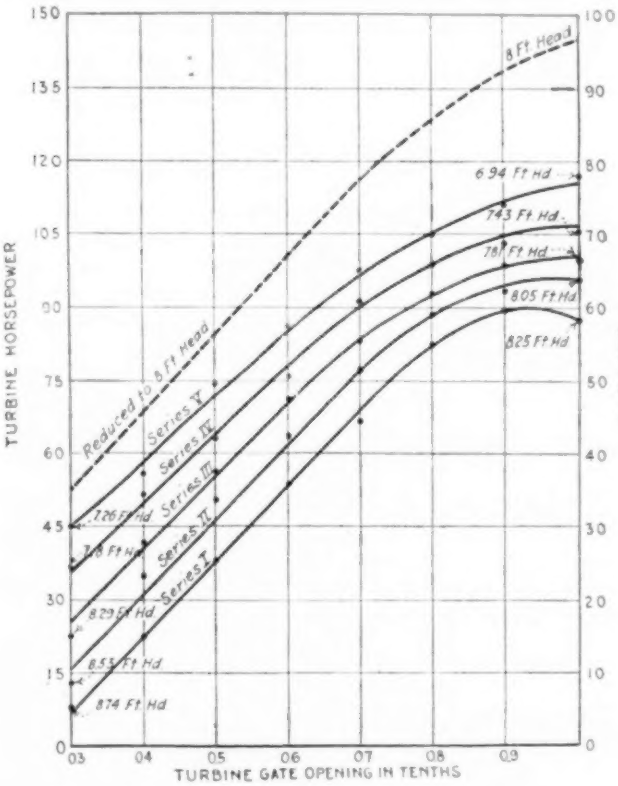

FIG. 4 RESULTS OF TESTS ON ACCELERATOR

turbine can have its capacity practically doubled under the same head, if sufficient water is available. The power unit can develop its normal rated power at one-half head when sufficient water is available, and the turbine can furnish considerable power when the working head is less than 25 per cent of the normal head, and all this may be done at good efficiency.

A like reflection will show that with this system many water powers may become independent of steam or gas reserves, with the saving of the large expense these auxiliary power units now entail. With the accelerator, too, it is not necessary to provide so many power units in a given development, as the elasticity permits of good efficiency with fewer turbines.

There are very many cases in which low heads only are available and the water cannot be utilized practically and profitably. The accelerator can be used to boost the head in such cases to an amount at which development of the water power is possible. The accelerator can convert an actual head of 3 to 10 ft. into a working or effective head of 8 to 20 ft.

OIL ENGINE VAPORIZER PROPORTIONS

BY LOUIS ILLMER, READING, PA.

Member of the Society

This paper is a synopsis of a research study to determine the proper proportions of hot bulbs for oil engines. The study was begun by the author a number of years ago when he was called upon to fix vaporizor dimensions suitable for Hornsby-Akroyd oil engines of large capacity. A careful investigation of the underlying principles brought out the design data here presented and from these data hot-bulb oil engines in sizes up to 100 b.h.p. have been built and operated with satisfactory results. Recently this investigation has again been taken up and has been largely extended so as to include proportions for high compression oil engine vaporizers.

In the hot bulb oil engine, of which the well known Hornsby-Akroyd engine is the prototype, the vaporizer heated by the gases of combustion provides a hot surface for the double purpose of evaporating the heavy mineral oils in the fuel oil and of maintaining the confined mixture charge at a temperature high enough to enable self-ignition to be induced with moderate compression. Fig. 1 is a sectional view of the vaporizer generally applied to a single-acting 4-stroke cycle Hornsby-Akroyd stationary oil engine. The vaporizer is of cast iron and forms a chamber, the outermost end or cap of which is unjacketed and maintained at approximately incipient cherry-red heat by the absorption of heat from the working charge. The spray nozzle is arranged to direct the oil against the hot surface of the vaporizer cap; the hot gases confined within the vaporizer from the previous charge evaporate the highly atomized particles of the injected oil, while the heavier particles impinge against the hot cap wall. Part of the heat required for evaporation of the oil is therefore supplied from the gases in the vaporizer and part from the vaporizer cap; the latter is the major part.

The essential principles of operation are: The oil is sprayed into the vaporizer chamber in the same period that a volume of air is sucked into the power cylinder. At the end of the suction stroke, the superheated oil vapor or gas in the vaporizer will have been mixed with approximately half of the hot products of combustion, while the body of air in the cylinder is confined there by the vaporizer neck. During the compression stroke, a certain portion of this air is forced through the neck at relatively high velocity, and is projected into the center of the highly heated oil-gas. This results at first in a supersaturated mixture of oil-gas and air being formed within the cap enclosure, the mixture being kept at a temperature considerably above ignition point by the heating effect of the products of combustion. Self-ignition will occur, therefore, at the instant the further addition of air makes this mixture of such proportions as to be explosive. Owing to this rather complicated action, the vaporizer dimensions must be exactly suited to the requirements, or the engine will not operate satisfactorily.

From the proportional analysis of some design data deduced from a fully developed line of horizontal 4-stroke Hornsby-Akroyd oil engines, it was found that the one simple relation suitable for design purposes was that of vaporizer volume to piston displacement. The other design factors depend upon more involved relations and center about the average tempera-

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ture attained by the unjacketed cap portion of the vaporizer wall.

The temperature relations existing in a hot vaporizer cap are best treated on the basis of a thin flat disc receiving a uniform heat input over one of its faces. Under conditions of equilibrium, the resulting heat flow will cause a temperature drop between the center and edge of the disc.

Let θ_1 = temperature of disc at center, deg. fahr.

θ_0 = temperature of disc at edge, deg. fahr.

$\theta = \theta_1 - \theta_0$ = temperature drop from center to edge of disc

r = radius of disc, in.

s = uniform thickness of disc, in.

H = uniformly distributed gross heat input in B.t.u. per hr. per sq. in. of area

k = specific thermal conductivity in B.t.u. per hr. per sq. in. of section at 1 deg. fahr. head

= about 3.82 for cast-iron.

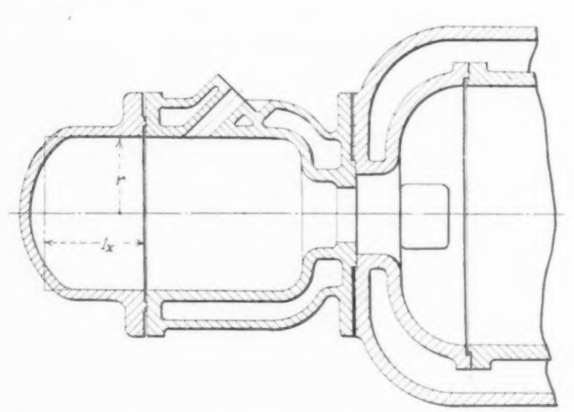


FIG. 1 VAPORIZER FOR SINGLE-ACTING 4-CYCLE OIL ENGINE

Since the temperature gradient, i.e., drop per inch of length, is proportional to the rate of heat flow, the gradient in the case of a cast-iron vaporizer cap will be equal to 1 deg. fahr. for each 3.82 B.t.u. flow per hr. per sq. in. of section. Applying this to a disc of radius r, the heat input will be measured by the area enclosed, multiplied by the uniform rate of input per sq. in. of surface. Assuming all of this heat is to be conducted to the edge of the disc, the rate of heat flow through the peripheral sectional area will be equal to

$$\pi r^2 H \div 2 \pi r s = \frac{H r}{2 s}$$

Dividing this equation by the constant k, the corresponding temperature gradient at the edge radius, r, will be equal to

$$\frac{H r}{2 k s}$$

This shows that the temperature drop per unit of length is directly proportional to the disc radius; and since the heat flow at the center of the disc is zero, the average temperature gradient will therefore be ½ that at the full radius, r.

The total temperature drop from center to edge of a thin disc will then be equal to the average drop per unit length multiplied by the disc radius, r, that is, for the disc

$$\theta = \theta_1 - \theta_0 = \frac{1}{4} \cdot \frac{H r^2}{k s} \quad \ldots\ldots\ldots\ldots\ldots [1]$$

Applying the same reasoning to the case of a relatively thin internally heated tube whose inner radius is r and length is l (both in inches), and in which all the heat is conducted away at one end, it will be found that the total temperature drop over the full length is equal to

$$\theta = \theta_1 - \theta_0 = \frac{1}{2} \frac{H l^2}{k s} \quad \ldots\ldots\ldots\ldots\ldots [2]$$

The temperature drop over a tube is dependent only upon the length of the tube, and for unit length the drop is twice that for a disc of unit radius.

The temperature distribution as determined by either of equations [1] or [2] is plotted in Fig. 2. The maximum temperature, θ_1, corresponds to that of the center of the disc or of the free hot end of the tube, while the disc edge or attached tube end assumes the temperature θ_0.

Numerical values for the counter-temperature, θ_0, vary with the size of the engine and the character of joint between the cap and jacket part of the vaporizer. In the case of the Hornsby-Akroyd vaporizer cap, a fair average value for θ_0 is 450 deg. fahr. under full load conditions.

If to the counter-temperature, θ_0, be added the average temperature ordinate under the curve, Fig. 2, then the average temperature, t_c, attained by the cap may be taken as approximately equal to

$$t_c = \frac{2}{3}(\theta_1 - \theta_0) + \theta_0 \ldots\ldots\ldots\ldots\ldots [3]$$

In treating the case of a bumped head, such as is shown in Fig. 1, a simple and fairly reliable method is to resolve the cap volume into an equivalent cylindrical depth, l_x, enclosed by a flat plate end, as indicated by the dotted line in the figure. The corresponding contour length for heat travel, taken in terms of tube length, will then be equal to

$$\frac{r}{2} + l_x = l_e \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [4]$$

where l_e = equivalent tube length in in. of the combined contour of tube and disc.

The input surface in this case will be the area of the disc plus the area of the cylindrical length, l_x, which is exactly equal to the interior surface of a cylinder having a length of l_e. Hence this factor may be inserted into equation [2] without further surface correction, thus

$$\theta = \theta_1 - \theta_0 = \frac{H l_e^2}{2 k s} \ldots\ldots\ldots\ldots\ldots\ldots [2a]$$

The thickness, s, in the line of Hornsby-Akroyd engines referred to, is fairly well represented by the relation

$$s = 0.075 \, l_e \ldots \quad \ldots\ldots\ldots\ldots\ldots [5]$$

When the cap is projected into the vaporizer and receives heat over a portion of its face in the manner indicated in Fig. 3, the counter-temperature, θ_0, is increased. The derived formulæ apply only to the disc portion of the surface which is directly exposed to the heating action of the hot gases, while the temperature drop over the length, d, of the protected tubular section of Fig. 3 should be taken proportional to the amount of heat conducted to the edge of the disc.

The case of an offset cylinder head, Fig. 4, receiving heat at a uniform rate of input over its entire surface is best treated by considering the shape as a whole and finding its equivalent tube length having an internal radius r_b. The equivalent tube length to be added to compensate for the flat closing head is given by the above formulæ; but in determining the equivalent length to be added for the annulus at the other end of the tube, due allowance must be made for difference of thickness, area and contour length as compared with that of a disc.

Before numerical results can be obtained by means of equation [2a], a value must be fixed for the heat input factor, H. Owing to the cyclic nature of the heat flow, the quantity of

heat that will pass into the vaporizer cap wall may be taken as proportional to the average temperature head maintained with respect to the hot cap multiplied by the square root of the rate of such temperature applications.

For the purpose of further simplification, it is assumed that the temperature of the exhaust gases is approximately equal to that of the cap, so that the interchange of heat to and from the cap during all but the power strokes may be regarded as negligible. This holds true of Hornsby-Akroyd engines, because the temperature of the hot exhaust gases enclosed by the cap is approximately 1300 deg. fahr. at full load.

Under the assumed conditions, fairly reliable values for the uniformly distributed heat input factor, H, may be based upon experimental determinations of gas engine jacket losses and may be taken as follows:

For 2-stroke cycle engines

$$H = \frac{t_h}{8}\sqrt{\frac{N}{100}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

and for 4-stroke cycle engines

$$H = \frac{t_h}{11}\sqrt{\frac{N}{200}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

where N = engine speed in r.p.m.

t_h = effective temperature head in deg. fahr. as measured by the average temperature maintained during expansion with respect to the heat-absorbing jacket wall

H is in B.t.u. per sq. in. of cap surface per hr.

These formulae hold good only for relatively hot caps.

In case the vaporizer is subjected to external radiation, all of the heat absorbed by the vaporizer cap wall will not be conducted to the edge of the disc, as is assumed in the derivation of the above formulæ. The radiation loss of a vaporizer at red heat may be approximately compensated for on the basis of 10 B.t.u. per sq. in. per hr. uniformly distributed over the interior cap surface.

Another modifying factor of heat flow is the cooling action due to the evaporation of such portion of the injected fuel oil as may take heat out of the cap wall. This loss is likewise most conveniently allowed for by assuming it to be uniformly distributed over the entire surface of the cap.

As previously pointed out, the injection of fuel oil tends to cool the hot products of combustion confined within the vaporizer. The degree to which these hot gases contribute to the evaporation of the fuel oil depends in part upon the thoroughness of atomization. Without elaborating on this point, it might be said that in the Hornsby-Akroyd engine apparently about one-third of the full load oil is vaporized by the hot gases and the hot cap imparts the necessary heat of evaporation to the remaining two-thirds of the full load fuel oil and superheats this oil gas to a temperature of about 900 deg. fahr.

The quantity of oil required by an oil engine operating on the explosive cycle can be determined approximately from the following full load indicated efficiency formula:

$$E_i = 1 - \frac{1}{R^{n-1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

where E_i = indicated efficiency

R = ratio of expansion (about 3⅓ for the Hornsby-Akroyd engine)

n = exponent in formula $P\,V^n = C$ as based upon the expansion line. For most explosive oil engines of the vaporizer type, n may be taken at about 6/5.

The total heat of evaporation for fuel oil remains fairly constant throughout a wide range of densities, and for the purpose of the present investigation it may be taken as approximately

$$q = 165 + \frac{t_t}{3} \quad \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

where q = total heat in B.t.u. required to evaporate 1 lb. of fuel oil from 70 deg. fahr.

t_t = deg. fahr. to which the oil-gas is heated.

An estimate can now be made of the total cooling action resulting from external radiation plus that due to the gasification of fuel oil by the cap. This heat taken on the basis of unit cap area, will be designated by h, and its numerical value varies from 10 to 25 per cent of the gross input heat, H.

Having thus fixed upon that portion of the input heat that is not conducted to the edge of the disc, a correction for the dissipated heat can be embodied in equation [2a] by taking the temperature drop from end to end of the tube proportional to the net or actual heat flow, thus

$$\theta = \theta_1 - \theta_0 = \left(\frac{H - h}{k}\right)\frac{l_e^2}{2\,s} \quad \ldots\ldots\ldots [10]$$

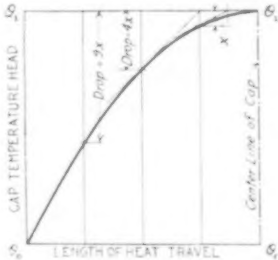


FIG. 2 VAPORIZER CAP TEMPERATURE HEAD

where h = dissipated heat in B.t.u. per hr. per sq. in. of cap area, i.e., difference between the gross input heat and the net quantity actually conducted to the end of the tube.

The heat consumption of an engine per cubic foot of cylinder displacement can readily be shown to be equal to

$$0.185\frac{P_m}{E_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots [11]$$

where P_m = mean effective pressure in lb. per sq. in.

The maximum attainable mean effective pressure is dependent, in part, upon the amount of fresh air per cubic foot of displacement that is available for fuel combustion. In a 4-stroke cycle explosive oil engine in which the compression pressure crosses the atmospheric line at about 9/10 stroke the full-load mean effective pressure to be expected from a properly proportioned explosive mixture bears a constant relation to the indicated efficiency, and may be taken as approximately equal to

$$P_m = 200\,E_i \quad \ldots\ldots\ldots\ldots\ldots\ldots [12]$$

Combining [11] and [12], it will be seen that the full load heat consumption of a 4-stroke cycle oil engine is practically constant at 37 B.t.u. per cu. ft. displacement, and that this is independent of the compression pressure. This means that, in terms of fuel oil having a heating value of about 18,500 B.t.u. per lb., a 4-stroke cycle engine may be expected to burn about 0.002 lb. oil per cu. ft. of displacement at full load.

The maximum temperature of combustion may be approximately estimated on the basis of a full-load input of 37 B.t.u. per cu. ft. displacement, as found above. The air sucked into

a hot 4-stroke cycle cylinder may be taken at about 0.05 lb. per cu. ft. displacement, and allowing for the high temperatures prevailing in the cylinder after the instant of explosion, the specific heat at constant volume may be assumed at 0.25. The resulting theoretical temperature rise must be reduced to allow for the considerable cooling action of the cap wall; in the case of the Hornsby-Akroyd engine, the actual temperature rise does not exceed three-quarters that expected on the unjacketed basis.

The full-load temperature rise in the cap of the Hornsby-Akroyd vaporizer, resulting from the combustion of the oil-gas mixture, is probably not far from 2000 deg. fahr., and if this be added to the initial temperature, the maximum temperature of combustion may be fixed at about 2800 deg. fahr. At lighter loads the temperature rise will naturally be reduced in proportion to the oil requirements.

The temperature at point of release or end of expansion period is then equal to

$$T_4 = (1 - E_1)\,T_3 \qquad [13]$$

where T_4 = temperature of release, absolute

T_3 = temperature of combustion, absolute

and hence the desired net temperature head driving the heat into the cap wall is given by the equation

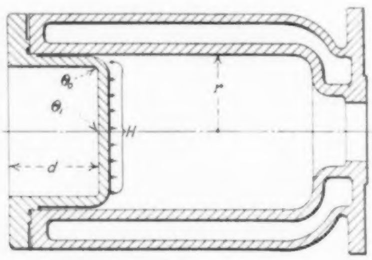


FIG. 3 VAPORIZER CAP PROJECTING INWARDS

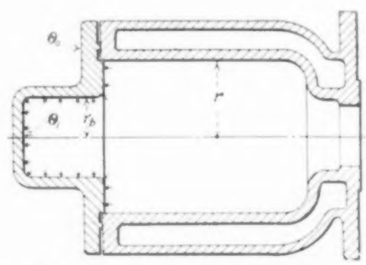


FIG. 4 VAPORIZER CAP PROJECTING OUTWARDS

$$t_h = t_a - t_c = \left(\frac{T_3 + T_4}{2} - 460\right) - t_c \qquad [14]$$

where t_a = average temperature during expansion stroke, deg. fahr.

Numerical values for all the required factors having been finally fixed upon, the various equations may now be combined to find a value for the cap temperature, t_c. This must be taken with due allowance for the decreased heat input with rise of temperature in the cap wall. For a 4-stroke cycle engine, this condition is satisfied by substituting in equation [3] and transposing,

$$t_c = \frac{\left(t_a\sqrt{\frac{N}{200}} - 11h\right)\frac{l_c^2}{33\,k\,s} + \theta_0}{1 + \sqrt{\frac{N}{200}}\,.\,\frac{l_c^2}{33\,k\,s}} \qquad [15]$$

Taking k for cast iron equal to 3.82 and confining the equation to the line of Hornsby-Akroyd oil engines, the above can be further simplified by substituting for the thickness, s, equation [5]. Accordingly at full load,

$$t_c = \frac{0.13\,l_c\left(t_a\sqrt{\frac{N}{200}} - 11h\right) + 450}{1 + 0.13 l_c\sqrt{\frac{N}{200}}} \qquad [16]$$

From these formulæ, the expected cap temperature for an oil engine vaporizer may readily be estimated. The equations also hold good for partial loads, provided the numerical values of t_a and θ_0 are suitably modified. A check shows the cap temperatures to vary approximately as the square root of the per cent of full-load oil used. It will be seen that since the cap temperature formulæ contain a speed factor, the cooling off of the cap under slow speed and light loads tends to limit the speed control of the engine.

The air sucked into the hot cylinder of a Hornsby-Akroyd engine may be assumed to have an initial temperature of about 250 deg. fahr. This air, taken at 0.05 lb. per cu. ft. piston displacement, when compressed to about 45 lb. per sq. in. gage, will be confined in a volume just about equal to that of the vaporizer. Since a portion of this air must remain in the clearance space behind the piston, only about one-half of the cylinder intake air will be forced into the vaporizer by the time the piston reaches its inner dead center. This amount of air weighs only about 12 times as much as the injected full-load oil and is insufficient for complete combustion. However, immediately after explosion of this charge, a portion of the ignited supersaturated mixture is sent forth through the contracted neck, when it is made to intermingle with the required amount of surplus air lying in the space behind the receding piston.

Oil-gas assumes explosive proportions when the air content of the mixture reaches about two-thirds of the air required for complete combustion, i.e., about 10 parts of air to one of oil by weight. Such a mixture will ignite of itself at a temperature of about 750 deg. fahr. Assuming that air in proportion of about 10 times the fuel weight to have been forced into the vaporizer at the end of the compression stroke, the hot products of combustion may be expected to raise the temperature of the entire vaporizer content of a Hornsby-Akroyd engine to 750 deg. fahr., ignition temperature when running on one-third to one-half of the oil used at full load. Below this critical point, the temperature head, t_h, is reduced to such an extent that the cap no longer keeps the enclosed gases sufficiently preheated to reach the ignition temperature at the end of the compression period.

A corresponding check made for full-load conditions shows that, due to the higher exhaust and cap temperatures, the average mixture temperature in the vaporizer will be raised to about 800 deg. fahr. This increase of temperature causes an advance in the ignition timing, and at heavy loads may lead to the characteristic pounding that accompanies serious pre-ignition unless counteracted by water injection.

Here the author develops the following formula for the minimum allowable vaporizer volumes for high compression engines:

$$\frac{V_v}{V_0} = \frac{1 - \left(\frac{P_2}{400}\right)^{\frac{\;}{n}}}{\left(\frac{P_3}{400}\right)^{\frac{1}{n}} - \left(\frac{P_2}{400}\right)^{\frac{1}{n}}} \qquad [17]$$

where V_0 = total clearance volume of engine (including vaporizer)

V_v = required volume of vaporizer

V_c = clearance volume external to vaporizer

P_3 = maximum explosion pressure, absolute

P_2 = compression pressure, absolute

n = exponent in $P\,V^n = C$

Numerical results derived from equation [17] are shown plotted in Fig. 3, from which it is evident that equalization of pressure cannot occur in the sense assumed unless the compression pressure exceeds 135 lb. per sq. in. gage. Hence engines operating at less than this compression should have their vaporizer volume made equal to the entire clearance space. This requirement may be obviated, and the vaporizer volume reduced by about one-third, when working with a supersaturated mixture and projecting the ignited oil-gas into the surplus air lying outside the vaporizer, as practised in the Hornsby-Akroyd oil engine.

The moderate preheating requirements of a high compression oil engine allow self-ignition to be attained without maintaining the vaporizer cap at full red heat. This reduces internal strains and makes the cap better able to withstand fatigue without cracking. Furthermore, the increased ratio of expansion in the high compression engine lowers the exhaust temperature, and in case the vaporizer cap is to be maintained at an average temperature considerably higher than that of the exhaust gases, due allowance must be made in the given

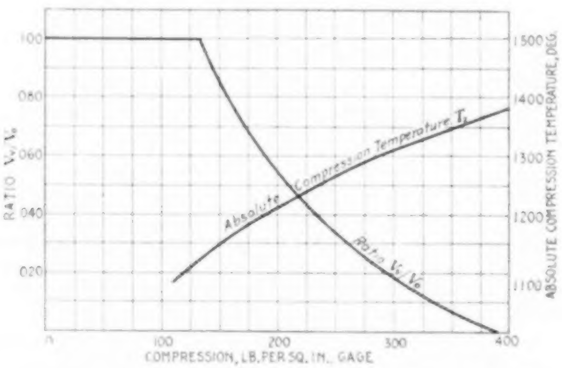


FIG. 3 CURVE GIVING VAPORIZER VOLUME

formulæ for the cooling action occurring during the idle strokes.

The elimination of the idle suction and exhaust strokes, make the 2-stroke cycle especially applicable to hot-bulb oil engines; it not only improves the frequency of impulse, but also admits of wider speed variation without ignition failure. By carrying the compression in the vaporizer beyond the self-ignition limits, the engine can be proportioned to operate through a much greater speed range than is possible with the low compression Hornsby-Akroyd type of engine.

Comparing the high compression vaporizer type of oil engine with the Diesel engine, it may be pointed out that the former is lower in first cost and the net fuel economy is little, if at all, inferior when working with a compression pressure above 300 lb. per sq. in, gage. Among other advantages, the vaporizer engine embodies simplified construction, obviates extremely high pressures, increases mechanical efficiency, lowers the power loss required for air injection of the fuel oil, lessens operating skill required on the part of the attendant and to a considerable degree reduces the danger of destructive explosion.

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

Provisions have been made by the Publication Committee for Correspondence Departments in The Journal as follows:

A Department for contributed discussions on papers previously published, or new matter.

A Members' Correspondence Department including suggestions on Society affairs.

Contributions for these departments are earnestly solicited.

AN OPPORTUNITY FOR THE SOCIETY

TO THE EDITOR:

I wish to suggest an answer to one of the questions you ask on page 2 of the November, 1915, issue of The Journal as to how the work of the Society can be extended.

In my opinion, one way of doing this is to draw the attention of the membership to the desirability of inducing the Federal Government to bestow the same favor on engineering that has been accorded to agriculture, that is, to pass a law establishing Engineering Experiment or Research Stations at the Land Grant Colleges. The Society might well be given the privilege of supervising this work.

In order to satisfy the constantly increasing need and demand for engineering research work in this country, we should have an appropriation beginning the first year with \$15,000 and an annual increase of \$5,000 per year for two years, making a total annual sum of \$25,000, to be paid each state and territory for maintaining a Research Station. This money should be used for no other purpose than research along engineering lines.

The staff at these stations should be composed, in the beginning, of three engineers, all of whom should be "thirty-two years of age, or over, and in actual practice of their profession for at least ten years and in responsible charge of important work for five years, and qualified to design as well as to direct engineering work." One of these should be designated Director.

As soon as the appropriation has increased to an amount permitting, one more engineer should be engaged, thus completing the staff of four engineers at each station.

The Federal Director of these stations should be first, an engineer and second, a good business man.

In the selection of these engineers it should be of the highest importance to choose men whose records show their ability to think scientifically, and in order to secure able engineers for these stations, I feel that one-half of the appropriation should be used for the salaries of these four engineers, the balance to be expended for apparatus, labor, etc., in connection with the experiments.

We need research on this scale in order to keep pace with the other world powers. We need it to improve the quality of our materials and to perfect our processes and methods.

In asking for this appropriation of one and a quarter millions dollars in round numbers annually, we cannot promise a regular return to the Government in the form of direct earnings, but we can promise an indirect return in course of time of many million of dollars in the form of increased wealth of manufacturing, increased tax returns on manufacturing property, also increased exports of improved machinery and merchandise.

CHAS. MILLS.

Riverside, Cal.

WORK OF THE BOILER CODE COMMITTEE

The Boiler Code Committee of the Society, after completion of its report on Rules for the Construction of Stationary Boilers and Allowable Working Pressures, as announced in the March 1915 issue of The Journal, was continued by the Council as a Committee to make such revisions as may be found desirable in the Rules and to modify them as the state of the art advances.

A resolution was passed by the Council of the Society empowering the Committee to make rulings where inquiries are made respecting constructions not covered by the Code and to interpret any parts of the Code. The various inquiries have been given careful consideration by the Committee, each being given a case number under which it is filed in the records of the Committee, which are preserved at the office of the Society.

The procedure in the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed on at a regular meeting of the Committee. This interpretation is submitted to the Council for approval, after which, it is issued to the party making the inquiry and later published in The Journal, in order that any one interested may readily secure the latest information concerning the interpretations.

Since the first meeting for issuing interpretations which was held in Buffalo at the time of the Spring meeting of the Society, three additional meetings have been held by the Committee. Forty-six inquiries have been considered. Of these interpretations have been given for all but three, which are still in the hands of the Committee. Below are presented synopses of the forty-three cases for which interpretations have been issued. In general it has been thought advisable to refrain from the publication of the names of inquirers.

The Code was published in Volume 36 of the Transactions.

Case No. 1

Inquiry: Should the crown sheet of the vertical single flue boiler shown in Fig. 1 be stayed or braced as a flat surface?

Reply: The strains in a boiler of this design cannot be calculated, and it is the expressed desire of the Committee that such a boiler of the particular size and make be tested to destruction in the presence of the Ohio state inspector and the inspector of an authorized insurance company doing business in the State of Ohio.

Case No. 2

Inquiry: A ruling is desired relative to the method of supporting water tube boilers by head supports attached directly to the heads of steam drums, in order to enable the drums to be set close together.

Reply: Where forces other than than those provided for in the Code are applied to steam boilers or other pressure vessels, the strain imposed by such forces must be calculated and additional strength provided to withstand them, using a factor of safety not less than that prescribed for similar conditions in the Code.

Case No. 3

Inquiry: Can flange steel be used in the shells of locomotive, marine and vertical tubular boilers in construction under the A.S.M.E. Code? In other words, is it to be understood that fire-box steel will be required only where the plates are exposed to the fire or products of combustion?

Reply: In accordance with Pars. 2 and 3, flange steel may be used in shells of such boilers.

Case No. 4

Inquiry: Is there anything in the Boiler Code to prohibit a third return of the products of combustion in the setting of a horizontal tubular boiler, by turning arches over the same? It is also a common practice in heating installations where locomotive type boilers are used, to return the products of combustion around and over the top of such boilers by arching them in.

Reply: There is no mention of, nor provision for the passing of products of combustion over the tops of boilers and this arrangement is thus not prohibited by the Code. However, if such third-pass arrangement is used and the products of combustion come in contact with the shell or dome of a boiler, it would be necessary that the boiler be constructed entirely of fire-box steel to comply with Pars. 2 and 3 of the Code.

Case No. 5

Inquiry: Can the quadruple-riveted butt and double strap joint, illustrated in Fig. 2, be used under the rules of the A.S.M.E. Code? On quadruple-riveted joints, only a few rivet pitches can be put in a course of a shell, and it is often very difficult to get in a good spacing of rivets. This proposed spacing gives the designer more leeway. It is the same as the quintuple riveted joint shown on p. 102 of the Code.

Reply: There is nothing in the Code to prohibit the use of the proposed arrangement, providing the rules in the Code with respect to joints are complied with.

Case No. 6

Inquiry: The upper cut on p. 103 of the Code shows an impossible joint for boiler construction. The distance between the outer rows of rivets is too great and therefore the joint does not permit of calking tight.

Reply: The criticism is justified only when butt straps are thin. This type of joint is in common use in this country and abroad with heavy plates.

Case No. 7

Inquiry: Is the bushing specified in Pars. 307 and 315 considered necessary to more securely hold the pipe in the head? If this is the case, does not a lip pressed outwardly around the feed pipe perform the same function and could it not be included under the same specifications?

Reply: Much better construction would result by forming or pressing into the dished head a flat spot in which can be inserted a regular steel or brass bushing, as required by the Code. The intent of the brass or steel boiler bushing is to allow the pipe to be threaded in solid from each side; that is, from the inside or outside of the boiler.

Case No. 8

Inquiry: The title of the Code on the cover and page 1 reads, "Construction of Stationary Boilers," which is not correct. The Code does not cover stationary boilers only; it covers portable, semi-portable and traction boilers and the term is therefore misleading.

Reply: The interpretation given to the word "stationary" by the Committee is that stationary boilers in general are considered land boilers or non-marine boilers. Further, stationary boilers are construed in some interpretations to be applied to boilers in vessels where the vessels are not propelled by the steam generated in them, such as pile drivers and donkey boilers of steamships and barges. It was therefore decided unwise to amplify or describe the word "stationary" in detail.

Case No. 9

Inquiry: Is it allowable to publish extracts from the Code in a text book for students, where the quotations are not arranged in the same sequence as in the Code, but where all quotations are literally in the language of the Code, each paragraph being

preceded, as a distinguishing mark, by the paragraph number of the Code and by quotation marks?

Reply: The publication under the conditions outlined is allowable.

Case No. 10

Inquiry: Please advise as to where the boiler stamp specified in Par. 332 of the Boiler Code may be obtained?

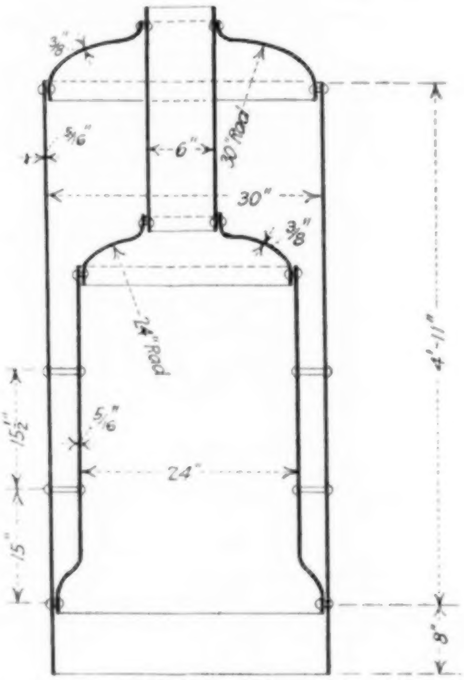


Fig. 1 A Design of Vertical Single Flue Boiler

Reply: At the meeting of the Boiler Code Committee of The American Society of Mechanical Engineers in Buffalo on June 24, 1915, the wish was officially expressed by the Committee that all A.S.M.E. boiler stamps be obtained through The American Society of Mechanical Engineers, 29 West 39th Street, New York. Stamps have been placed on sale by the Society, and may be obtained at the nominal price of $3.00 each.

Case No. 11

Inquiry: Does Par. 248, in which the drilling or punching and reaming of the tube holes is specifically provided for, apply to handhole openings as well?

Reply: Par. 248 applies only to tube holes and thus does not refer to handhole openings, and there is no provision in the present rules providing for the machining of handholes.

Case No. 12

Inquiry: Objections are raised to the action of the Ohio Board of Boiler Rules in rejecting a particular design of house heater safety valve as not conforming to the requirements of the A.S.M.E. Code, on the basis of the rules that prohibit adjustment for a higher pressure than 15 lb., and that prohibit location or piping so that there will be danger of scalding attendants.

Reply: It is the judgment of the Committee that the Ohio Board is entirely correct in its interpretation of the provisions of the Code.

Case No. 13

Inquiry: Please give an interpretation of the application of Pars. 205, 206 and 207 to the staying of locomotive type wet bottom boilers, such as are used in portable or traction service, with particular reference to the details shown in **Fig. 3**.

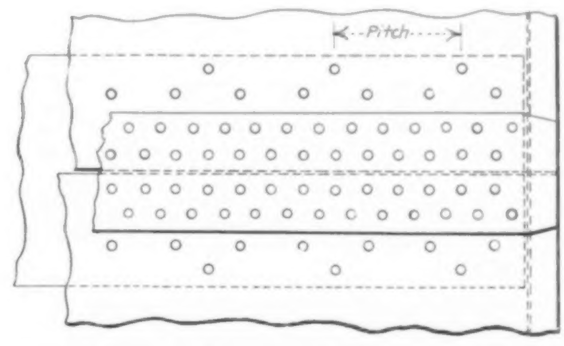


Fig. 2 A Design of Quadruple-Riveted Butt and Double Strap Joint

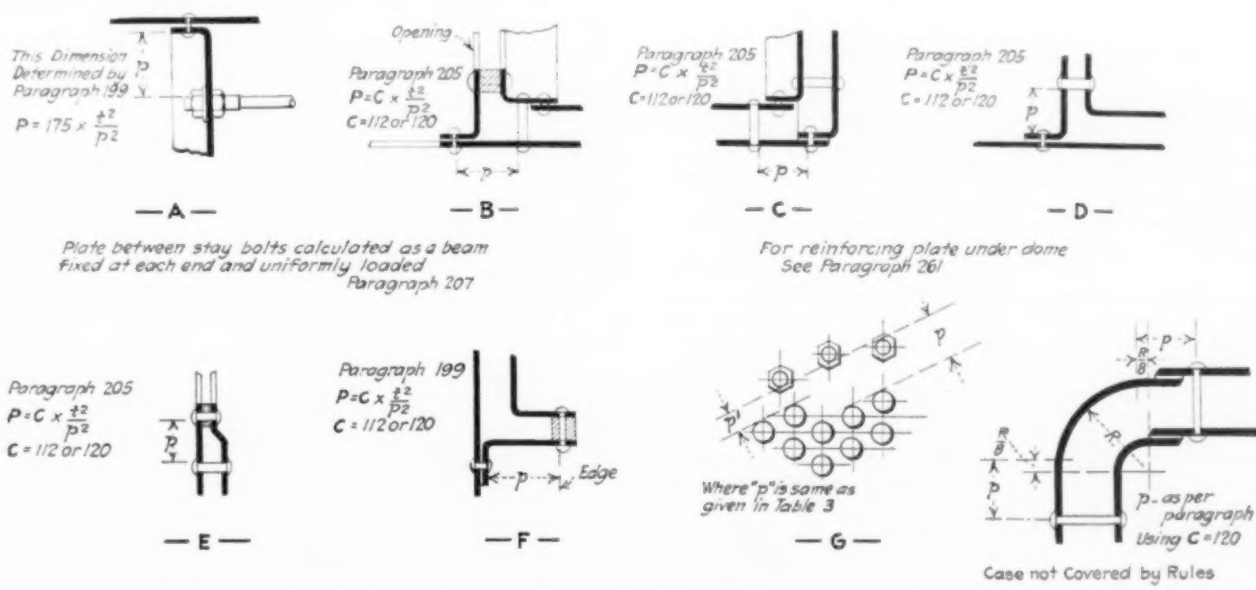


Fig. 3 Details showing Application of Pars. 205, 206 and 207 to the Staying of Wet-Bottom Boilers

Reply: Fig. 3 has been prepared to show the application of Pars. 205, 206 and 207 to eight possible cases where uncertainty may arise in the staying of boilers of this type, each of which is shown with a reference to a paragraph and a formula indicating the value of p together with the value of the constant.

An additional case not covered by the rules is also shown. The matter of reinforcing plate underneath the dome is answered by reference to Par. 261 of the Code.

CASE NO. 14

Inquiry: Is Par. 5 which apparently requires all manhole and handhole covers to be made of pressed steel, consistent with Par. 262?

Reply: It was found that the punctuation in Par. 5 in the first edition of the Code was incorrect and the paragraph has been repunctuated as follows: "5 Manhole and handhole covers and other parts subjected to pressure and braces and lugs, when made of steel plates, shall be—" etc.

CASE NO. 15

Inquiry: Is it allowable under Par. 195, to use the longer radius in calculating the thickness of a concave head having two different radii?

Reply: It is perfectly safe to use the longer radius in calculating the thickness of heads having two different radii.

CASE NO. 16

Inquiry: Is it possible to omit the constant in the formula in Par. 193, which handicaps the construction of drums with the tube spacings illustrated in Fig. 4? It is considered that the staggered relation of the tube design shown in Fig. 4 is equally as strong as if the tubes were put in parallel rows. Can this not be proved to the satisfaction of the Committee by a test to destruction of drums constructed in this manner?

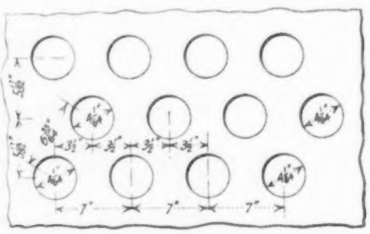


FIG. 4 DIAGONAL SPACING OF TUBE HOLES IN STEAM DRUM

Reply: The particular spacings of $5\frac{3}{4}$ in. and 7 in. for staggered 4 in. tubes, do not come within the range of the formula in the Code for diagonal ligaments, and as long as these particular spacings and size of tubes continue to be used, the efficiency of the tube sheet may be figured on the longitudinal ligament.

CASE NO. 17

Inquiry: *a.* Referring to the provision that all fire doors of water tube boilers are to be provided with latches, how can a fireman be expected to make use of such a device?

b. The specification, staybolt iron, is so drastic as to prohibit its use in the boiler business, which is a misfortune because staybolt iron is a better product for use in water tube boilers than staybolt steel.

c. Is not the thickness required by the formula for dished heads excessive. They are vastly beyond all previous practice.

d. Referring to Par. 191, how is it proposed to form the ends of a 72 in. shell by rolling? This involves so much extra labor when applied to shell plates that doubtful benefits are secured at much too high a cost.

Reply: *a.* The provision of latches on fire doors of water tube boilers was made in the interest of safety.

b. The requirements of the Code relative to staybolt iron are a direct copy from the American Society for Testing Materials specifications for that class of material.

c. This particular formula (Par. 191) in the Code, was determined after the most careful consideration and it will be inexpedient to consider any change.

d. In regard to the rolling of boiler shells, this is one of the most important features in the proper construction of boilers, and the Committee trusts that arrangements may be made in constructing boilers to meet the requirements of the Code.

CASE NO. 18

Inquiry: What is the purpose of Pars. 307 and 315, requiring boiler bushings? In locomotive type boilers it has been a practice to take the feed pipe through the fire door sheet, although in some cases, due to interference of external construction it has been necessary to have the firedoor in the side of the fire box instead of at the end. In these cases, it is also impracticable to introduce the feed water through the fire door head, and it is then introduced through the shell plate, using a reinforced plate riveted to the shell and threading both plates.

Reply: Par. 315 of the Code applies only to horizontal return tubular boilers. It was the intention of the Committee to make the use of a boiler bushing obligatory only when an internal pipe is used.

CASE NO. 19

Inquiry: Is it the intention of Par. 200 to allow the use of hollow staybolts in lieu of drilled staybolts,—at any rate for small bolts?

Reply: It was the intention of the Committee, as expressed in Par. 200, to permit the use of hollow staybolts, whether drilled, forged or made of tubing.

CASE NO. 20

(In the hands of the Committee)

CASE NO. 21

Inquiry: An explanation of the meaning of Par. 207 is desired. Apparently this matter is specifically covered in Par. 199.

Reply: This paragraph was arranged so that manufacturers could space stays wider than allowed by Table 3, providing stiffeners be used to keep the stress within prescribed limits; for illustration handholes where edges of plates are turned in.

CASE NO. 22

Inquiry: Is the term, "length of furnace" in Par. 239 intended to mean the length of the longest section or the length from end to end?

Reply: The length of furnace, referred to in Par. 239, is the total length and not the length of a section.

CASE NO. 23

Inquiry: Where a manhole is located in the head of a horizontal tubular boiler above the tubes, how should the arrangements of braces around the opening be provided for? It is possible that Par. 203 would cover in the case of handholes, but would not some additional provision for spacing be required in the case of manhole openings?

Reply: Par. 203 is not intended to be applied to the spacing of crowfeet or the spacing of through braces across any opening.

CASE NO. 24

Inquiry: Please state the correct procedure,

(*a*) to design an A.S.M.E. Code Boiler; it is understood that it is only necessary to follow the Code and that drawing need not be submitted for approval.

(*b*) to obtain authority to use the A.S.M.E. Code Boiler stamp; it is understood that this is supplied by the Society at a cost of \$3.00 upon application in the form of an affidavit which prescribes its usage and is to be surrendered to the Society immediately at any time upon request.

(*c*) after obtaining the stamp to build the boiler; when an order for an A.S.M.E. boiler is received, it is understood that an insurance company is to be notified that an inspection is to be made of it.

(*d*) in handling inspections of boilers; it is understood that two inspections are made,—one before the riveting up and one as a final test:

(*e*) in the stamping of the boiler after completion; it is understood that the builder shall stamp the boiler in the presence of the inspector, with the A.S.M.E. Code stamp, the builder's name and the serial number of the boiler as well as the insurance company's or State stamp.

(*f*) in making report of inspector's data; it is understood that the inspector's data slip is turned in to the chief inspector and that a record must be made of all that is in same.

Reply: The understanding relative to Inquiries *a* and *b* as to the procedure necessary in commencing construction of an A.S.M.E. Code boiler, is correct. As to *c, d, e* and *f*, the matter of any insurance company certifying as to the correctness of the Code stamp is a question of contract between the manufacturer and the insurance company adding the stamp, and of the law in the case of a State stamp, over which the Committee has no jurisdiction.

Case No. 25

Inquiry: Referring to Pars. 268, 307 and 315, must the boiler feed and surface blow-off pipes be bushed in all types of boilers, including the locomotive type as well as the vertical submerged tube type?

Reply: Par. 315 of the Code applies only to horizontal return tubular boilers. It was the intention of the Committee to make use of a boiler bushing obligatory only when an internal pipe is used.

Case No. 26

Inquiry: Is it necessary to furnish mill test reports covering physical test and chemical analysis of material used in braces?

Reply: Attention is called to the specification for steel bars on p. 19 of the Boiler Code, which specification a builder will be called upon to follow for braces to be used in boilers constructed in strict accordance with the Code. Attention is also called to Par. 6 of the Code.

Case No. 27

Inquiry: An interpretation is requested on Par. 223, which does not state that the rivet holes must be drilled from the solid.

Reply: Any or all rivet holes in boiler construction may be punched 1/4 in. small and drilled or reamed to full size thereafter.

Case No. 28

(In the hands of the Committee)

Case No. 29

Inquiry: Is the boiler brace shown in the accompanying sketch, where the end section left in the foot of the brace is smaller than called for by Par. 223, within the requirements of the Code?

Reply: It is the judgement of the Committee that all braces used in A.S.M.E. Code boilers should conform to the Code in every detail.

Case No. 30

Inquiry: Attention is called to the fact that the requirements of the Code for safety valves specifying a lifting device so attached that the valve disc can be lifted from its seat a distance of one-tenth the nominal diameter of the valve, requires an exceptionally strong lever, possibly of the cam type, and that the present types of levers are not satisfactory.

Reply: The requirements for safety valves were made after conference with the principal manufacturers of the country and it goes without saying that the Code requirements apply to all manufacturers and all designs.

Case No. 31

Inquiry: Is not a pressed steel flange for surface blow-off connection superior to an ordinary bushing screwed into the boiler shell, as provided for in Par. 307?

Reply: It is the intention of the Committee to make the use of a boiler bushing obligatory only when an internal pipe is used. The idea in specifying the boiler bushing is to have the internal pipe screwed in solid into a substantial fitting. Whether or not the plate should be reinforced where the bushing is screwed in depends on its thickness to give the required number of threads in accordance with Par. 268.

Case No. 32

Inquiry: The latter part of Par. 199 is understood by some to set a limit on the thickness of doubling plates; is this so?

Reply: It was not the intention of the Committee to limit the thickness of doubling plates that might be used on a boiler, but it was intended rather that the strength added by the application of a doubling plate should be limited to that which would be provided by a plate of equal thickness with the head to which it is applied; that is, for cases where doubling plates are thicker than the head of the boiler, the value of "t" shall be taken as 3/4 of the double thickness of the head.

Case No. 33

Inquiry: Can safety valves of any size be connected to boilers by the use of nipples and threaded flanges? There appears to be a conflict between Pars. 268 and 286.

Reply: Par. 286 applies to the form of connection of a safety valve to a boiler. Par. 268 makes no reference to the form of connection.

Case No. 34

Inquiry: Does Par. 254 apply to the butt joints in the shell only, or to other riveted joints on boilers also?

Reply: Par. 254 refers specifically to plates and butt-straps collectively, whether reamed or drilled.

Case No. 35

Inquiry: Is it intended that Par. 292 apply to all designs of automatic water gages when there is one design in which an entire stoppage of either valve is impossible?

Reply: After careful consideration of this question, the Committee has decided to interpret Par. 292 as follows: No water glass connection shall be fitted with an automatic shut-off valve, except when the automatic shut-off valves are so constructed that the two connections to the water glass can be blown through separately and the steam connection cannot be entirely closed thereby.

Case No. 36

Inquiry: Does Par. 355 mean that a safety valve with a threaded side outlet must be used or can a valve with top outlet or one which exhausts directly into the atmosphere be used?

Reply: A safety, or water relief valve designed for a discharge pipe will comply with the requirements of Par. 355; safety or water relief valves without provision for a discharge pipe may comply with the requirements of Par. 355 provided the valve is so located that there is no danger of scalding the attendants.

Case No. 37

Inquiry: Can forged steel flanges of 4 in. pipe size, with a thickness of 1 1/8 in. be used on boilers built to carry 175 lb. pressure? Table 16 requires a thickness of 1 1/4 in.

Reply: In regard to the thickness of flanges and bodies for nozzles and fittings, Tables 15 and 16 for the American Standard have been prepared for cast iron as a material, and until a flange committee prepares a table for steel, the Boiler Code will permit an allowable variation of 20 per cent from the thickness required by the above mentioned tables, leaving the drilling of bolt holes unchanged. Special forged fittings shall conform with respect to diameter of flanges and bolt circle, but otherwise need not conform.

Case No. 38

Inquiry: Is it required that every boiler stamped with the symbol illustrated in Fig. 19 of the Boiler Code, should also be stamped with the form shown in Fig. 20?

Reply: This inquiry is answered by the ruling given in Case No. 24 as follows: "Certifying to the correctness of the Code stamp is a question of contract between the manufacturer and the insurance company adding the stamp, and of the law, in the case of a State stamp, over which the Committee has no jurisdiction.

CASE NO. 39

Inquiry: Referring to Par. 299, which states: "Where the maximum allowable working pressure is less than 125 lb. per sq. in., Table 15 shall be used and where higher Table 16," a ruling is requested as to whether or not Table 15 is to be used for 125 lb.

Reply: The intention of Par. 299 is that Table 15 shall apply where the maximum allowable working pressure is 125 lb. per sq. in. or less.

CASE NO. 40

Inquiry: Referring to Par. 223 of the Code which calls for each branch of the crow-foot of boiler braces to carry two-thirds of the total load of the brace at the allowed stress, and for the net sectional areas to be at least equal to the required rivet section, exemption is asked for a special form of brace, as it is believed that this ruling applies to braces that are divided in the center of the crow-foot.

Reply: The design submitted is such that it does not come within the requirements of the Code. These rules have been formulated after thorough consideration of the stresses, and are in accord with sound practice.

CASE NO. 41

Inquiry: Referring to Par. 299 and Tables 15 and 16, it is understood that these requirements are based on flanges and fittings of cast iron; is it intended that these same tables shall apply to flanges of steel?

Reply: In regard to the thickness of flanges and bodies for nozzles and fittings, Tables 15 and 16 for the American Standard have been prepared for cast iron as a material, and until a flange committee prepares a table for steel, the Boiler Code will permit an allowable variation of 20 per cent from the thickness required by the above mentioned tables, leaving the drilling of bolt holes unchanged. Special forged fittings shall conform with respect to diameter of flanges and bolt circle, but otherwise need not conform.

CASE NO. 42

Inquiry: In Par. 323, the third sentence apparently applies only to boilers over 78 in. in diameter and specifically only to boilers suspended from over-head girders; has it any application to boilers provided with lugs resting on brackets?

Reply: Par. 323 applies only to boilers over 78 in. in diameter: such boilers must be suspended. Therefore, the paragraph relates only to lug supports of boilers over 78 in. in diameter.

CASE NO. 43

Inquiry: Par. 223 of the Code requires that: "The net sectional areas through the sides of crow-feet, T irons, or similar fastenings at the rivet holes, shall be at least equal to the required rivet section; does this refer to the blades of diagonal braces where attached to the shell of the boiler?

Reply: Par. 223 refers to blades of diagonal braces as they are similar fastenings to crow-feet or T irons. This means that the net section at the rivet holes of the brace should be at least $1\frac{1}{4}$ times the required cross sectional area of the body of the brace.

CASE NO. 44

Inquiry: A ruling is requested relative to a design of boiler in which cross drums are suspended below the shell of the boiler and exposed directly to the fire, so that they necessarily act as receptacles for mud and sediment and can only be classed as mud drums; as these are placed in direct contact with intense heat, they are considered contrary to modern practice and not of safe construction.

Reply: The Committee has decided that it will not express opinions on types of boilers, and it will therefore be impossible to comply with your request for an opinion.

CASE NO. 45

(In the hands of the Committee)

CASE NO. 46

Inquiry: With reference to the design of boilers for 500 to 600 lbs. pressure, the test pressure as specified in the Boiler Code would be prohibitive and give a larger factor of safety than could be expected with commercial construction. Can a modification be made that would permit the construction of such boilers at a commercial cost?

Reply: All requirements of the Code should be complied with irrespective of the working pressure. The Committee feels this is not an unreasonable requirement for commercial construction.

Society Affairs

Engineering Survey

SOCIETY AFFAIRS

THE Annual Meeting of the Society in New York, December 7-10, was a pronounced success socially as well as from a technical viewpoint. The registration exceeded all former records, and as a result the excursions and social affairs in connection with the Meeting were unusually well attended. The "Smoker," an innovation at this Meeting, met with the approval of the visiting members and its repetition at later meetings was strongly urged by all. An account of the social features of the Meeting follows.

THE ANNUAL MEETING

The Thirty-sixth Annual Meeting held in New York December 7-10 inclusive was a great success. There was a record attendance of 1437, of which 819 were members. Members were present from every section of the country, and fourteen Local Sections were represented by delegates, two of whom were from California. A feeling of enthusiasm was manifest, which found voice in various ways during the meeting. As reported elsewhere, there was a series of conferences of representatives of the Local Sections at which "Extend the Local Sections" was the watchword; and at these conferences the delegates proceeded to plan ways and means for accomplishing this end. At the Council meetings the sentiment expressed was equally prophetic. The spirit of democratization was in the air and action started toward a fuller control of the government of the Society by the membership at large.

It is probable that few members realize the great amount of work assumed by the Committee on Meetings in preparing the program for the Annual Meeting. The examination of the many papers submitted is itself an arduous task for busy men, besides the work of arranging an acceptable program and deciding the many questions which arise. The committee is always ably assisted by the New York Local Committee, who have charge of the social events, and this year unusually valuable contributions to the professional program were rendered by several of the local and professional committees. Seven papers were contributed by Local Sections and thirteen, including reports, by professional committees. By this means the papers are not only becoming more representative of the engineering work of the country as a whole, but are selected through intimate acquaintance with the subjects to be discussed and the mature judgment of the expert engineers who constitute the different committees.

PRESIDENT'S ADDRESS

Never, on a Tuesday evening of a convention of this Society, has there been so large an audience to listen to the presidential address as greeted Dr. John A. Brashear in the large auditorium of the Engineering Societies Building at the opening session. Dr. Brashear spoke in his always delightful manner on Science in its Relation to Engineering, and the manuscript of his address is appropriately given first place in this number of The Journal.

Following the address Calvin W. Rice, Secretary, reported for the Tellers of Election of Officers the election of the following:

For President:
D. S. Jacobus, New York.

For Vice-Presidents:
Wm. B. Jackson, Chicago, Ill.
J. Sellers Bancroft, Philadelphia, Pa.
Julian Kennedy, Pittsburgh, Pa.

For Managers:
John H. Barr, New York.
John A Stevens, Lowell, Mass.
H. de B. Parsons, New York.

For Treasurer:
Wm. H. Wiley, New York.

Past-Presidents Ambrose Swasey, S. T. Wellman, and W. F. M. Goss then escorted the President-Elect, Dr. D. S. Jacobus, to the platform, where Dr. Goss presented him as "one who had brought great honor to the profession and who for many years had unselfishly devoted himself to the work of the Society," and said that it was most fitting that he should now guide its destinies.

Dr. Brashear greeted Dr. Jacobus and said that he hoped the new President would have as good a time as he had had during his term of office and that he would have as cordial support as he had received from the membership. He referred to the Council meeting of that afternoon at which several resolutions were passed for the good of the Society at large, looking to the extension of its representative character, so that all its members "from Maine to California and from the Gulf to Canada" would have as great a voice as possible in the conduct of its affairs. Dr. Jacobus replied briefly, saying that this was the proudest moment of his life.

As is customary, the audience then adjourned to the rooms of the Society on the eleventh floor of the building where a reception was tendered to the President and President-elect and their friends.

ENTERTAINMENT FEATURES

It has become the custom for the ladies to hold a reception and serve tea in the rooms of the Society during one afternoon of the Annual Meeting, and as usual this event contributed much to the pleasure of those in attendance and gave the members an opportunity for a social hour at the end of a strenuous day of professional meetings.

On Thursday Mrs. Harrington Emerson entertained the ladies delightfully at luncheon at the Hotel Astor. About one hundred ladies enjoyed her hospitality on this memorable occasion.

In the matter of entertainment for the visiting members an innovation was introduced in the way of a smoker held in the rooms of the Society on Wednesday evening in place of the usual Wednesday evening lecture. To say that the rooms were not only crowded but were packed to their utmost capacity indicates the popularity of such a form of entertainment and the opportunity for members to get together for the renewal of acquaintanceship. It is safe to say that the membership will desire to have this feature of the Annual Meeting repeated another year and it is also evident that much larger quarters will have to be arranged for to accommodate those who desire to attend. Expressions of approval of this smoker, which was arranged by the New York Committee, were heard on every hand.

On Thursday evening as usual there was a dinner and dance in the Grand Ballroom of the Hotel Astor, which was attended by 300 members and guests. Last year this took the form of a combined dinner and dance, with dancing between the courses. This year the dinner took place before the dancing, so that groups who desired to dine together would not be broken up until the conclusion of the banquet. A reproduction of a photograph taken at the banquet is shown herewith.

Group of Members and Guests at the Dinner Held in the Hotel Astor, Thursday Evening, December 9, 1915

EXCURSIONS

On the third and fourth days of the Annual Meeting, six excursions were made to points of engineering interest. These were organized by the Excursion Committee, and each party was in charge of a competent guide.

The places visited were the Woolworth and Municipal Buildings, the studio of the Vitagraph Company of America, the aviation field at Garden City, the Brooklyn Navy Yard, the Interboro Rapid Transit Company's 74th Street Station, and the Harrolds Motor Car Company. The guides were Messrs. W. H. Greul, F. A. Scheffler, L. Goldmerstein, A. D. Blake, E. D. Herbert, and C. P. Bliss.

At the Woolworth and Municipal Buildings, members were afforded an excellent opportunity of inspecting particularly the power plants—that at the former building being privately owned and that at the latter being Edison service—and the elevator equipments.

At the Vitagraph studio, the practical details of making moving pictures were shown the party, and a very enjoyable time was spent.

Various types of flying machines, including Huntington, Schmitt, Buranelli-Carisi, Gallaudet, Curtiss, Bellanca, Young, driven by different motors, including Curtiss, Gyro and Gnome, were inspected at the Garden City aviation field. Flights were made by biplanes of the Max. Schmitt Company and by the Gallaudet machine of the New York National Guard.

At the Brooklyn Navy Yard, the Diesel engines for the fuel ship Maumee were run on the testing floor by special arrangement. These engines are the largest yet constructed in this country, 2600 h.p. A number of large battleships, including the Arizona, now being fitted out at the yard, were inspected.

The Seventy-fourth Street Station of the Interborough Rapid Transit Company, also visited, supplies the elevated railway system of New York City. The plant contains three 30,000 k.v.a. cross-compound turbines.

At the Harrolds Motor Car Company, the party was afforded the opportunity of seeing Pierce-Arrow motor car trucks and cars assembled.

COLLEGE REUNIONS

Friday night at the Annual Meeting has now come to be regarded as College Reunion night. This year ten such reunions were held and the members of the Society were invited to all.

These functions were the annual dinner and theater party of the Alumni of Stevens Institute of Technology, a smoker given by the Engineering Alumni of Brown University, the annual dinner of the Mechanical Engineers of Cornell University, a reunion dinner and smoker of the New York Lehigh Club, a reunion of members of the Technology Club at the Chemists' Club, a reunion of the Mechanical Engineering Alumni of the Polytechnic Institute of Brooklyn in the rooms of the Society, a reunion dinner and smoker of the Purdue Club of New York, a reunion dinner and smoker of the Alumni of the University of Illinois and the annual dinner of the New York Alumni of Worcester Polytechnic Institute.

BUSINESS SESSION

The business session on Wednesday morning opened with the presentation of the report of the Council and of the standing committees, which were approved by the meeting. Secretary Calvin W. Rice in offering the reports called attention to the salient features of the report of the Council, which is published elsewhere in this number.

Following the presentation of the reports of the Council and standing committees, E. S. Sanderson, *Chairman* of the Committee on Standardization of Special Threads for Fixtures and Fittings, presented a report of his committee on Straight Pipe Threads. This is the second report which the committee has submitted, the first having been given at the last Spring Meeting on the subject of Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases.

Mr. Sanderson said that while the subject of the report of his committee seems like rather a small matter, it probably affects as many manufacturers of small thread devices as could be conceived. The matter was first brought to the attention of the committee by manufacturers of automobile devices who, when the change was made from acetylene lighting to electric lighting for automobiles, found that the threads did not interchange and investigation showed that a similar condition existed with regard to threads on gas fixtures, electric sockets, etc. The report had been submitted to practically all the societies whose members might be users of such fixtures and it had their approval with but slight modifications which did not affect the usefulness of the report.

Dr. D. S. Jacobus announced the completion of the report of the Committee on Power Tests and said that a number of years ago the committee was appointed to bring out a report, considering, however, existing reports on this subject which the Society had issued, and which to a certain extent had become standard through long use.

A great deal of work had been done, especially by George H. Barrus, *Chairman* of the committee, William Kent and A. C. Wood, who formed a sub-committee of the main committee. From time to time there were meetings of the entire committee and every member of the committee had given his approval to the final report which had now been prepared.

The work was to be brought out first in a limited edition with the idea that some typographical errors might be found and the committee had suggested to the Council, who had approved, that a permanent committee be formed to interpret any portions of the report about which there might be doubt.

It was moved, and carried by the meeting, that the report be accepted, with the request to the Council that the standing committee mentioned be appointed.

The next business related to amendments to the Constitution, the first of which proposed to change the present provision for a special nominating committee for officers of 20 or more persons to a special nominating committee consisting of one per cent of the voting membership.

There was considerable discussion of this amendment, indicating a question in the minds of many as to whether one per cent of the present membership, which now constitutes 5000 voting members, would not make it too difficult for any member or group of members to organize a special nominating committee.

William T. Donnelly said that he had known of no abuse of the provision as it stood whereby only 20 persons were required to constitute such a committee. He considered the Constitution an instrument which should safeguard the membership, and that technically and ethically all amendments to the Constitution should arise from the membership rather than the Council; and unless there was some reason for the change in this section of the Constitution of which he was not advised, he was in favor of the old form.

Charles Whiting Baker considered the change not to be in the direction of democratization of the Society. While he believed that the nominating committees had done their work without favor or prejudice, still he would leave a door wide

open so that the ordinary man could come in and make his own ticket by choosing 20 men to nominate a candidate for any office in the Society.

Dr. Jacobus explained that in accordance with the requirements this amendment had its first presentation at the last Spring Meeting, otherwise he would have prepared another amendment in the same line to make the nominating committee more representative of the entire Society. He thought it would be a good plan to have the chairman of each Local Section a member of the nominating committee. At the Council meeting the day before it was voted to do everything possible to carry out the democratization of the Society and every member was to be given a chance, "from Maine to California and from the Gulf to Canada" (as expressed by Dr. Brashear at the opening session), to have a voice in the nomination of the officers and of the members of the Council.

James E. Sague, member of the Committee on Constitution and By-Laws, said there was no intent of the committee to move against a fair representation by the membership, but that it was considered that one member out of each 100 of the voting members would be a more business-like number than the limitation of 20 members.

A motion to lay the amendment on the table was duly seconded and carried by a preponderant vote in the affirmative.

At this point the business of the meeting was suspended to do honor to the memory of the late Frederick W. Taylor, Past-President, by brief memorial exercises, an account of which appears elsewhere in this number.

At the conclusion of these exercises the second amendment to the Constitution was considered, relating to copyrighting the Society's publications. At the present time the Society copyrights none of its publications except the annual volume of Transactions. The proposed amendment provided that "The Society shall claim the exclusive copyright to any reports of its duly appointed committees. The Council shall waive such copyright for specific reports. The Society shall copyright all papers read before the Society printing thereon in each instance that the paper may be reprinted by anyone after the same had been read before the Society, provided that due credit be acknowledged to the Society and the author."

Arthur M. Greene, Jr., explained that the purpose of the amendment was to enable the Council to secure a copyright in order to insure the proper publication of any report by those outside of the Society. The question arose in connection with the Boiler Code where certain people wished to publish parts of the Code, and the Council felt it necessary to protect the Code by insisting that they get permission whenever it is desired to publish. The purpose is merely to give the control of any publication to the Society rather than to leave it in the hands of one who would like to republish a paper or a report without securing permission.

Dr. Hollis Godfrey asked what was the relation of the author to a paper so copyrighted. There should be a provision which would enable the Society to release the copyright to an author of a paper when he desired to publish it in the form of a book. Authors have experienced difficulty in securing the consent necessary to publish matter of their own in book form when it has previously been copyrighted. The discussion by several others indicated that uncertainty existed as to whether this condition would obtain under the amendment as now provided, and it was finally moved and carried that the whole subject of copyrighting be laid on the table to give an opportunity for further consideration. The business meeting now adjourned and the first professional session began.

PROFESSIONAL SESSIONS

At this first session two papers were presented for discussion, on The Design of Fire Tube Boilers and Steam Drums, by F. W. Dean, and A Novel Method of Handling Boilers to Prevent Corrosion and Scale, by Allan H. Babcock. The latter paper was read by Mr. Babcock's assistant, Mr. Fred E. Geibel, who had come from San Francisco for this purpose. This paper provoked considerable discussion and it was a late hour when the meeting adjourned.

At this meeting also six papers were listed and distributed in pamphlet form for presentation by title only, and upon which written discussion was solicited for publication in The Journal. Five of these papers were contributed by Local Sections of the Society.

On Wednesday afternoon three simultaneous sessions were held respectively by the Sub-committees on Textiles, Machine Shop Practice, and Railroads. At the Textile Session the papers were on Higher Steam Pressures, Robert Cramer; Heating by Forced Circulation of Hot Water in Textile Mills, Albert G. Duncan; Relative Value of Private and Purchased Electric Power for Textile Mills, Frank W. Reynolds; and The Engineer and the Business of Fire Insurance, Joseph P. Gray.

At the Machine Shop Session there were two papers upon the Automatic Control of Machine Tools by L. D. Burlingame and L. C. Brooks, together with a Report of a Safety Code for the Use and Care of Abrasive Wheels, which had been put in the hands of the Sub-committee on Machine Shop Practice after consideration by a committee of the Machine Tool Builders Association and some other organiaztions.

A feature of the Railroad Session was a paper by a distinguished Honorary Member of the Society, Anatole Mallet of Paris, France, on the Operation of Parallel and Radial Axles of a Locomotive by a Single Set of Cylinders. A paper was also given on Four-Wheel Trucks for Passenger Cars by Roy V. Wright.

On Thursday morning there were two simultaneous sessions, one on Power Plants and one with Miscellaneous Papers. Those relating to Power Plants were The Heat Insulating Properties of Commerical Steam Pipe Coverings, L. B. McMillan; Performance and Design of High Vacuum Surface Condensers, Geo. H. Gibson and Paul A. Bancel; Circulation in Horizontal Water Tube Boilers, Paul A. Bancel; and Unique Hydraulic Power Plant at the Henry Ford Farms, Mark A. Replogle.

The papers of the Miscellaneous Session were headed by the Junior Prize paper for 1915 on The Flow of Air Through Thin-Plate Orifices, by Ernest O. Hickstein. This is the first paper to receive a prize from The American Society of Mechanical Engineers. The donation of the prize was made possible by a fund for Student and Junior Prizes recently established by a member of the Society. The other papers at this session were Elasticity and Strength of Stoneware and Porcelain, by James E. Boyd; Foundations, by Charles T. Main; and Oil Engine Vaporizer Proportions, by Louis Illmer.

The last session was a session of general interest and of a semi-technical nature under the direction of the Sub-committee on Protection of Industrial Workers with the following papers which drew out a considerable amount of discussion: Standardization of Safety Principles, Carl M. Hansen; Modern Movement for Safety from Standpoint of Manufacturer, Melville W. Mix; The Attitude of the Employer towards Accident Prevention and Workmen's Compensation, W. H. Cameron; and Industrial Safety and Principles of Management, W. P.

Barba. This was the last session with Dr. Brashear in the chair as President of the Society, and he closed the meeting with a few remarks expressing his thanks to every member of the Society. He explained how when the nomination had been offered him he felt that his other duties would prevent his serving the Society, but he finally agreed to accept if he could be relieved of minor duties. As had proved he found the major duties quite sufficient, for he had traveled 12,500 miles since the first of September, to say nothing of his earlier trips, for the purpose of meeting members and friends of the Society in different parts of the country and for delivering lectures before different sections and other associations in the country.

TRIBUTE TO F. W. TAYLOR AT ANNUAL MEETING

As a tribute to the late Dr. Frederick Winslow Taylor, Past-President of the Society, who died on March 21, 1915, the regular business of the Wednesday morning session of the Annual Meeting was suspended at 11 o'clock a.m. for a period of an hour, during which was held a memorial meeting to Dr. Taylor.

It was the desire of the Society, after the distressing news of Dr. Taylor's early death, to show honor to his memory in some fitting way, and in May last, the Council appointed a committee consisting of Henry R. Towne, *Chairman*, John R. Freeman, Prof. Frederick R. Hutton and Oberlin Smith, for the purpose of preparing a memorial.

This committee learned later of the service in memory of Dr. Taylor to be held in Philadelphia in October by the Society to Promote the Science of Management. An account of this remarkable service, which was conducted on Friday, October 22, in Houston Hall, University of Pennsylvania, and at which many leaders in management and personal friends of Dr. Taylor were present, was given in the November issue of The Journal.

At the Annual Meeting, Mr. Towne said it was the intention of his Committee to include in its report an account of the proceedings of the Philadelphia service, and that it would ask leave from the Society to print the full report of the Committee in Volume 37 of Transactions as a lasting tribute to Dr. Taylor's memory.

Brief addresses were then given by Mr. Towne, Mr. H. L. Gantt and Rear-Admiral Casper F. Goodrich, all intimate friends of Dr. Taylor, referring to various phases of his life and work, accounts of which follow.

Henry R. Towne. Science is defined as "knowledge gained by systematic observation, experiment and reasoning." That is the Baconian system, and this was followed by Mr. Taylor throughout his whole professional career. He not only aimed to acquire knowledge, but did acquire it, and out of the knowledge so acquired he created a new science, and, emphatically, he is entitled to be classed as a scientist as well as an engineer. Mr. Taylor's achievements were not the result of sudden impulse or inspiration,—they were the fruition of years of patient investigation, study, toil, experimentation and intense application of his admirable reasoning faculties. One of the most notable of his traits to all who have followed his career and to those of us who knew him was the endless pertinacity with which he pursued an object to which he had once turned his serious attention, and the work which he did was ever pursued in the true spirit of research.

"Facts, not opinions," is a motto which peculiarly applies to the life and methods of Mr. Taylor. He was ever seeking to get *facts*, to understand those facts correctly, to analyze them, and to apply them to useful ends. That is true throughout the whole of his wide range of work, but above all to his study of facts concerning human nature and their application to industrial work and management.

True to the spirit of the scientist, Mr. Taylor never rushed into print. Like Charles Darwin, before giving the world the results of his studies and discoveries he waited long years to assure himself of the facts and that his deductions from them were sound. He began his career at Midvale in 1878. His first public utterance on the subject of industrial management was in 1886, and then only as a discussion of a paper presented by Metcalf. His first paper on the piece-work system was not presented until 1895, after fifteen years of investigation and study, and his classic paper "The Art of Cutitng Metals," presented in 1906, came out only after twenty years of research. He spoke only when he had a message, and then always with absolute modesty. One could always feel that the man was not presenting himself, but his topic, and that that possessed him, that he was trying to present what he believed to be a new and interesting truth for the world to consider.

Mr. Taylor's major publications constitute a remarkable list. His first was in 1886 on "The Relative Value of Water Gas and Producer Gas for Open Hearth Furnaces," a short publication of only eight pages. In 1893 came his "Notes on Belting," the most comprehensive address on the subject the world had ever had up to that date, which was accepted as the basis for all further studies and investigations, and is practically the authority to-day on all the phases of the subject to which it relates. In 1895 was issued his "Piece-work System," the first paper on the subject. In 1899 he and Mr. White wrote a short paper of great interest and importance on "Colors of Heated Steel." In 1903, he brought out his first elaborate paper on the subject of "Shop Management," and for the first time presented to the world what we now call commonly the "Taylor System." In 1905 was issued his book on "Concrete," of which a third edition is in press to-day, and in 1906 came his paper on "The Art of Cutting Metals," 246 pages, which was epochal in its significance and importance, and finally in 1911 his complete gathering together of his "Facts and Arguments on the Subject of the Principles of Scientific Management," a book of 144 pages. What a record for twenty-five years! How wide the range of subjects, how long and thorough the study, and how complete his summing up of them!

Mr. Taylor was born in Philadelphia, in 1856, and attended the Germantown Academy as his early school. Then he was sent to school in France and Germany, and afterward spent a year and a half in an enjoyable trip to nearly all of continental Europe, and then two years at Exeter Academy preparing for Harvard University.

His eyes failed under the strain of his work and he had to give up the intention of entering Harvard. He entered a machine shop in Philadelphia in 1875, and for three years served his apprenticeship as a pattern maker and machinist, and there laid the foundation for the practical work which he took up later on. In 1878 he entered the Midvale Steel Works as a laborer and rose, in the short period of six years, to become chief engineer of the plant. One of his notable achievements while still a young man at Midvale was the successful design of a 20-ton steam hammer, which was novel in principle and daring in its features.

In 1883, while at Midvale, realizing his need for more thorough technical engineering education, he entered as a correspondence student of Stevens Institute, and by diligent and

earnest study secured his degree of Mechanical Engineer at the end of three years.

In 1890 he left Midvale and entered the employ of the Manufacturing and Investment Co., and for three years devoted himself to the reorganization of their large interests in Maine and Wisconsin, including in his work the design of two large pulp mills, and contributing many improvements to the processes and machines used in that special industry.

From 1893 to 1898 he worked out plans in five or six different establishments in Philadelphia and elsewhere, for remodelling their systems of shop management, and introduced many features of what afterward became known to all of us as the "Taylor System."

To whatever he turned his thoughts and his hands he gave concentrated attention, and in all cases he improved where he did not wholly originate. His range of work covered many fields and is an interesting chapter of human experience.

In 1901 he withdrew from salaried positions of all kinds. He had won a competence and was satisfied with it. His ambition lay not in that direction but in the carrying forward and upward of the work in which he had been so deeply interested and with which he was so closely identified, and he devoted himself from that time to the end of his life, without compensation, indeed even at the expenditure of much of his private means, to spreading the gospel of better industrial management.

In 1907 he was consulted by the United States Government in regard to the introduction of modern methods of management in its work-shops, arsenals and navy yards. In 1909 and afterward he frequently lectured on the subject of management and on kindred topics.

In 1906 the University of Pennsylvania conferred on him the honorary degree of Sc. D. and Hobart College that of LL.D. He was President of this Society in 1906, as well as being a member of many engineering and scientific organizations.

Mr. Taylor's was an abounding life. From youth to manhood and maturity it was brimming over with mental activity, an activity that flowed into many channels, but in each of them concentrated sooner or later upon some definite, specific object. He followed each object until a solution of the problem it presented had been worked out, and worked out so completely as to satisfy him, to make him willing to present the solution to the world.

In 1901 he said to one of his intimate friends: "I cannot afford any longer to work for money." That statement was typical of the man. Money was not an end with him but only a means, and having acquired the means to satisfy his reasonable desires his whole heart went into the furtherance of the work with which he had been identified through all his career.

His achievements were based primarily on his work at Midvale, and there he laid the foundations of nearly all the improvements with which he was afterwards identified, especially in regard to the cutting of metals, piece-work methods, the study of belting and shop management.

His books have been translated into many languages. His system has won world-wide recognition and increasing acceptance, and the tributes which were paid to him at the Taylor Memorial Services in Philadelphia, on October 21 and 22, 1915, were significant of the exceptional character of the man and his achievements.

As to the "Taylor System," the achievement with which his name is chiefly identified, there are many misconceptions. Most truly it is a science, and a new science. It is perfect in its simplicity and completeness. It is not piece-work, it is not differential rates, nor improved tools, nor time studies, nor routing plans, nor functional management, but it is all of these coördinated and combined, and above all, it aims to effect the uplift of the worker. Mr. Taylor aimed to show the workingman how to apply his time and efforts to better advantage and to accomplish more work than before in shorter time with less effort.

Sooner or later this fundamental fact in Mr. Taylor's work will be appreciated, and then the leaders of organized labor who, unwittingly, I like to think, thus far are opposing the introduction of the Taylor System, not only into Government plants but into private plants as well, will see their error and will lend their influence to promoting the introduction of a system which will do more than anything else that has been proposed in our day and generation for the uplift of labor.

Mr. Taylor saw the inequity of the old system of piecework compensation, under which increased efficiency and output, instead of being rewarded, were punished by a reduction of the piece-rate. I partly grasped that fact, and proposed in 1899 a method which would supply a partial remedy. Mr. Taylor grasped the full fact and furnished a remedy which completely solved the problem. His best monument is the Science which he created, and that will endure forever.

H. L. GANTT. It was my good fortune to be associated with Frederick Winslow Taylor, when, as a young man, he was developing those characteristics that were to make him famous.

His reputation does not depend upon the fact that he designed and built the most successful big steam hammer in the world, or that he developed a method of treating tool steel that trebled its cutting power, or that he determined the laws of cutting metals, or even that he was the father of scientific management. These were incidents in his career, and only the logical results of his methods. At an early date he realized how much of the world's work was based on precedent, or opinion, and undertook to base all his actions on knowledge and fact.

Endowed naturally with untiring energy and a wonderfully analytical mind, he concentrated all the power of that combination on the problem of determining the facts he needed. He was interested in what had been done, mainly for the indication it gave of what could be done. His mind was continually on the future, and to him the great value of knowledge was that it enabled him to anticipate that future. Accurate in his calculations and logical in his conclusions, he never failed to put his trust in the results of his investigations, and often accomplished what was considered by others to be impossible.

Balked at the outset of his career in 1880 by the lack of knowledge of cutting steel, which then existed, he set himself the task of supplying that lack. Three years were spent in finding out how to study the problem; and, although the work was not completed for over twenty years, it is a fact that when I entered his employ in 1887, the fundamental laws had already been approximately determined. Subsequent investigations served only to confirm what had been done, and to correct minor inaccuracies.

At Bethlehem he became so interested in determining these laws exactly, that it is doubtful if he ever realized how wonderfully accurate his earlier results really were. To be sure, much more ground was covered in the subsequent work, but as an investigation into the laws of cutting metals, his work as a young man at the Midvale Steel Works stands out, to my mind, as far the more remarkable achievement.

One of the by-products of this investigation was the dis-

covery of the Taylor-White process of treating high speed steel, the far-reaching effect of which has not only not yet been fully realized, but cannot be until all the other problems entering into machine shop management have been given the same kind of study as has been given the cutting of metals.

The least heard of, but, to my mind, his most daring feat, was the design of the great hammer of the Midvale Steel Co. This hammer was kept in alignment by the elasticity of its parts, which yielded to the force of a foul blow and returned exactly to their former position. Dependence upon the principle of elasticity enabled him to build a hammer which, for its weight, had far greater power than any other hammer that had ever been built.

Moreover, Mr. Taylor repudiated the theory that large bodies must move slowly, which had apparently been accepted by previous designers of large steam hammers, for few, if any had been supplied with top steam. He recognized the fact that large bodies could be made to move as rapidly as small ones, if only sufficient power were applied to them. Accordingly he supplemented a falling weight of 25 tons by 50 tons of top steam, and designed a hammer whose rate of action was nearly three times that of other hammers of the same class.

The fact that he became a pioneer in another field is not surprising, for he was destined to be a leader in whatever field his activities took him. It seems quite likely that if he had adhered to what was then known as strictly engineering, he would have made even a greater reputation than he achieved in the field of management.

The work by which he is best known, however, is not what was then regarded as strictly engineering. Strange as it may seem, although much knowledge and thought had been devoted to the design of machinery and apparatus, but little study had been given to the possibilities of the men who were to operate that machinery. Even to this day many engineers consider their work done when they have designed and built, and demonstrated the possibilities of a piece of apparatus. They seem to feel that the efficient operation of it is not in their province. Mr. Taylor felt otherwise. To him, perfection in design was worthless without efficiency in operation, and at an early date he turned his attention to the efficient utilization of human effort.

In this work he used the same methods that had already brought him success, namely, to disregard opinions, from whatever source, unless substantiated by facts. Where facts were not available, and they seldom were, he used the scientific method for their determination.

When I went to the Midvale Steel Works in 1887, he had already made considerable progress in this work, and had fully developed the methods of detail analysis and study, which later became the origin of scientific management.

He recognized as an economic as well as an ethical fact, that the employer should always consider the interests of the employee.

Endowed with vast energy and great ability to work, he recognized the advantage such qualities would be to others, and offered high wages to those who would develop them. That he was correct is shown by the remarkable success which has been attained by all who profited by his training.

Having determined on a course of action he pursued it regardless of consequences; and inasmuch as such courses were planned by a clear head and followed with an iron will, he often accomplished results far in excess of what even his most earnest supporters thought possible.

To end here would not complete our picture. He was not the steam roller that some people like to represent him, but he did believe that a strenuous life was the life worth while, and that it not only brought more financial compensation, but that it added to the usefulness and happiness of men.

He had still another side: People said he made work of his play. True, work was his joy. Not the routine that would be done by anybody, but the work that others had been unable to do. An unsolved problem was a constant challenge to him, and he attacked it with a thoroughness and an eagerness that it is hard to comprehend.

Rear-Admiral Casper F. Goodrich. It is always a great pleasure for me to speak of Dr. Frederick Winslow Taylor, and I thank you for the opportunity of again bearing witness, such as it is, to the man's remarkable character and his genius. I am familiar with a certain chapter in the life of Dr. Taylor which I think is unknown to the majority of you, and until very recently was not known to more than a mere handful of people.

I first met Mr. Taylor in 1885, when he was chief engineer of the Midvale Steel Works. I took a great fancy to him then, and I recommended him to the then Secretary of the Navy, Mr. Whitney, for the position of Superintendent of our great gun works at the Washington Navy Yard. I do not think that Mr. Taylor felt himself free at that time to accept the position, but at all events this recommendation brought him into relation with Mr. Whitney, and later when the latter started a certain line of manufacturing, he asked Mr. Taylor to take the position of general manager of the works. In that way I was associated with Mr. Taylor for a couple of years, very intimately, and I have maintained the friendship based upon that association up to his death.

I am indebted to him for a great many very valuable services. In 1907 I was sent as Commandant of the New York Navy Yard, where I found five separate industrial establishments within the yard, each one, in so far as it could be, complete in itself. Each one of these plants had been erected by one of the bureaus of the Navy Department,—there were buildings devoted to construction and repairs, ordnance, equipment, yards and docks, etc. This multiplication of plants was not conducive to economy, and I immediately saw the need for reform.

Mr. Truman H. Newbury, who was then Assistant Secretary of the Navy, and who later became Secretary, had charge of the navy yards at that time, and I went to him with the facts and I said: "Mr. Secretary, I will present to you no scheme, no proposition, that I have not already threshed out with the ablest engineer in this country. I do not pretend myself to be a mechanical engineer, but I do, fortunately, possess the friendship and the confidence of Mr. Frederick W. Taylor, and I will go over all these propositions with him and I will bring nothing before you that does not meet with his approval." Mr. Newbury, of course, knew all about Mr. Taylor and he liked to feel that any matter in the way of reform would be based upon the broadest and the wisest of grounds. He promised me the backing of the Navy Department. I consulted Mr. Taylor and we drew up a scheme and carried it out, and suffice it to say that with Mr. Newbury's authority and Mr. Taylor's advice we succeeded in concentrating the work of the Yard into fewer shops and in enormously decreasing the appropriation necessary.

I will only give one other illustration of what he did. There came over to my desk on one occasion a statement or schedule, as it is called, of the tool steel required at the different navy yards in only one of the departments. I was amazed at the

vast number of varieties of tool steel that were demanded by name, by brand, and in every case there was a certificate that none other would serve. I consulted Mr. Taylor who advised me to buy steel according to specifications and not by brand. I asked him if he would help me prepare specifications and he very quickly offered me all the assistance I required. So we prepared the specifications, which were later adopted by the Tool Steel Board appointed by Mr. Newbury to take up the question of the varieties of tool steel required, and their composition.

The first high speed steel that was bought under Mr. Taylor's specifications, as adopted and promulgated by the Navy Department, was for the gun works at Washington, and Admiral Leutzed, who was then in command, told me he had been previously paying $1.25 a pound for the steel required and he was now getting tool steel for from 32c to 36c a pound, and the new steel was doing about 33 1/3 per cent more work.

I thank you for this opportunity of claiming what I consider to be one of the greatest privileges of a long life, that of speaking of my former intimate and dear friend, Frederick Winslow Taylor.

Henry H. Suplee. A little story about Mr. Taylor which I do not think has been told anywhere might be of interest.

Mr. Taylor had some knowledge of the German language, and wished to perfect himself in it. Instead of hiring a teacher and studying a grammar, he set about to organize his own method of studying German. He got several of his friends together—there were about a dozen of us—and we were to meet once a week in his father's house in Germantown. He employed a teacher, not to teach him, but to do what he told the teacher to do. Then he devised a method of studying German, so that we could all learn to speak it fluently. It was his idea that if we attempted to play the game known as "Twenty Questions,"—a game in which twenty questions are asked in regard to various subjects, and those present gave the answers—and if we were obliged to answer the question in German, we would soon learn the language. If we made mistakes, it was to be the duty of the teacher to correct us. The teacher was not to instruct us in German, but to hold us down to the ordinary rules of good speaking, and to correct us if we made mistakes in our conversation with one another. We held meetings once a week for one winter and played this game and we were all fluent speakers in German at the end of that time.

ANNUAL REPORT OF THE COUNCIL

The Council herewith presents in brief the important phases of the Society activities during the year 1915, under the presidency of Dr. John A. Brashear. In reports published in the December Journal, the Standing Committees have given accounts of their work in detail. This year in the appointments by the President the plan was carried out so far as possible of having a member of the Council on every Standing Committee. The appointments on Standing Committees for the year were: Finance Committee, A. E. Forstall; Committee on Meetings, L. P. Alford; Publication, Henry Hess; Library, Jesse M. Smith; Membership, George A. Orrok and later Charles E. Lucke; House, O. P. Cummings; Research, R. J. S. Pigott, A. M. Greene, Jr.; Public Relations, Spencer Miller; Constitution and By-Laws, James E. Sague. H. A. Hey, Chairman, Robert H. Kirk, W. P. Hayes, and E. S. Cooley were appointed as Tellers of Election.

Membership. Under the guidance of I. E. Moultrop, Chairman of the Increase of Membership Committee, coöperating with the Membership Committee in keeping to high ideals of membership, there has been a steady increase in enrollment of the most representative men of the profession. Fig. 1 gives comparative data on the membership of the four national societies.

On account of the unusual conditions prevailing abroad and the inability of communicating with members there, foreign members of the Society have been continued on the rolls until further action of the Council.

The Society has lost by death during the past year, B. F. Isherwood, Honorary Member and two Past-Presidents, Fred W. Taylor and James M. Dodge.

The Council elected to Honorary Membership E. D. Leavitt, the second President of the Society, who served during one of the most difficult periods of its history. Mr. Leavitt is best known for his notable successes in the design of high-duty, compound pumping engines for city waterworks service and of engines and other machinery for some of the great mining operations of the country.

Local Sections. The Council at its January meeting appointed a Committee on Local Sections, the personnel of which is E. H. Whitlock, *Chairman,* Cleveland, Ohio; W. F. M. Goss, Urbana, Ill.; L. C. Marburg, New York; Walter Rautenstrauch, New York, and D. Robert Yarnall, Philadelphia. It is hoped by this means to develop and put on an efficient basis this important phase of the Society's work.

One of the first plans carried out by the Committee was a conference of section representatives held at the Spring Meeting in Buffalo. Delegates attended from Atlanta, San Francisco, Milwaukee, Chicago, New York, Providence, Philadelphia, Cleveland, Worcester and Birmingham, and so much of interest was developed that the Committee arranged for a second conference at the Annual Meeting. It is planned to make these conferences of local section chairmen a feature of either the Annual or Spring Meetings.

Local meetings have been held under the auspices of the several local sections committees in Atlanta, Boston, Buffalo, Chicago, Cincinnati, Los Angeles, Milwaukee, Minnesota, New Haven, New York, Philadelphia, St. Louis, San Francisco, and Worcester.

Coöperation of any local section of the Society with existing engineering organizations in the same city has been enthusiastically supported by the Council in the endeavor to promote general concurrence of all engineering societies in technical meetings. St. Louis has formed such an affiliation with the Engineers' Club of that city and the Philadelphia Local Sections' Committee with the Engineers' Club of Philadelphia.

New sections were established this year at Los Angeles, Cal., Worcester, Mass., and Birmingham, Ala.

Student Branches are established in 38 universities, representing a total enrollment of nearly 1,000. Branches have been added this year at Virginia Polytechnic Institute, and Georgia School of Technology.

Finances. The annual report of the Finance Committee, together with the auditors' report, covers fully the financial

status of the Society. In this connection the Council wishes to call attention to the fact that our life membership fund ($44,120.11), representing all that has been paid in for life memberships, is maintained as a separate fund and is invested. Similarly all the other trust funds and for quite a number of years all the initiation fees have been put into a fund and invested. From this latter fund, at a rate of $6,000 per year, we are retiring the certificates of indebtedness for the land on which the headquarters is built. We have thus accumulated $40,268.90 to offset the $54,100 of certificates of indebtedness. We have also $40,000 cash on hand, so, if we wished to, we could pay off all these certificates and be free and clear, but to do so, would leave little working capital. As we are doing a business of $150,000 a year, and discount all bills, it is economy to carry this extra cash, particularly as all our funds are invested at the same rate of interest as we are paying on the certificates.

Financially, we are one of the strongest engineering societies in the world, although we have secured far less by gift than many similar organizations.

Employment Work. There has been marked activity in the employment work this year. We have registered over 400 positions with firms who have asked our coöperation in securing men; this does not include recommendations of experts in consulting work of which we do not keep record but for whom we have many inquiries. We have definite record of over 100 men who have been placed in positions through the Society, and we are confident that this cannot represent the entire list as firms and individuals in many cases fail to advise the Secretary's office.

It may be of interest to note that the other national societies have now adopted this policy of assisting members to secure positions by bringing firms and men together.

Prizes for Technical Papers. The Society has received by bequest from the late Rear-Admiral George W. Melville $1,000, the income of which is to provide a gold medal to be awarded annually to such competing member of the Society who presents the best original paper or thesis. As an adequate die for a medal cannot be purchased out of the above fund, upon application to the Court the Society has been authorized to allow the fund to accumulate until sufficient to defray the cost of a suitable set of dies.

There was reported last year the receipt of $2,000, through the generosity of a member of the Council, from which fund there are to be awarded annually three prizes, one of $50, to a Junior and two of $25 each to student members who contribute the best original papers. It is felt that such awards will influence the young engineer to undertake original work. The committees in charge of awards are: For Juniors, R. H. Fernald, *Chairman;* Fred E. Rogers, George B. Brand. For students, Frederick R. Hutton, *Chairman;* R. H. Fernald, D. S. Kimball. One award was made this year for the paper, "Flow of Air Through Thin Plate Orifices," by Ernest O. Hickstein, Junior Member. As the papers submitted by students did not meet the requirements as to standard, no awards were made this year.

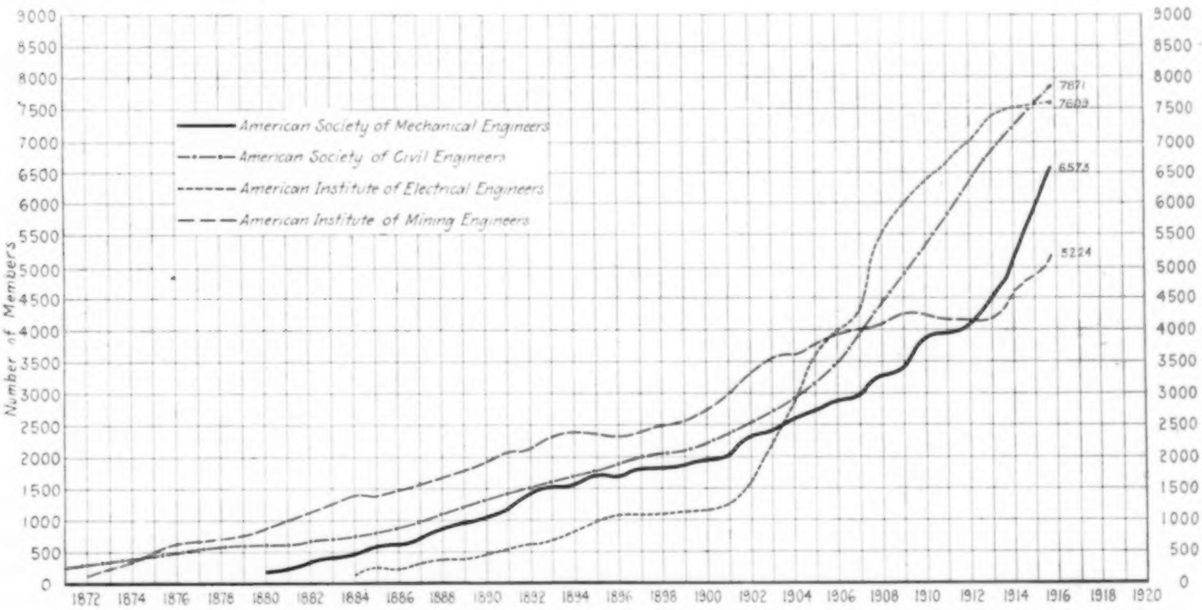


Fig. 1. Comparative Growths of Membership in the Four National Societies

MEMBERSHIP FOR YEAR 1914-15

Grade	Oct. 1, 1914	Losses				Additions		Net Increase	Oct. 1. 1915.
		Transfer	Resign	Lapsed	Death	Transfer	Election		
Hon. Mem.	14				1	1			14
Member	4077	1	29	36	38	33	328	257	4334
Assoc.	380	12	6	9	4	1	38	8	388
Assoc. Mem.	245				1	20	184	203	448
Junior	1274	42	25	24	2		212	119	1393
Total	5990	55	60	69	46	55	762	587	6577

Note—Affiliates, students' sections 955, a decrease of 36 since 1914.

Publications. The history of the Society from the time of its formation in 1880 through the year 1915, has been completed and issued uniform in size and binding with Transactions, with the exception of color which is dark green used to designate extra publications of the Society.

The Council has approved the plans of the Publication Committee as given in their report, which outlines a broad and progressive policy for the several publications of the Society.

COMMITTEE REPORTS

The Council has ruled that the signatures of members of the committee grouped as assenting or dissenting must accompany all reports. This ruling is covered in the following by-law:

"B-47. All written reports of all committees shall be presented to the Council. Each written report of every committee must be approved in writing by at least a majority of the members of that committee, before it is presented to the Council. A member of a committee who disagrees with the action of a majority of that committee may express his disagreement over his signature, either on the report of the committee or in a minority report. The minority report of any member of a committee if offered, shall be presented at the same time that the report of that committee is presented to the Council. All reports of committees must be first received by the Council who shall prescribe the manner in which they shall be presented to the membership of the Society and be made public and printed."

Boiler Code. On the completion of the report of the committee having in hand the preparation of a code for steam boilers, the original committee and its advisory committee were reappointed as one committee to be known as the Boiler Code Committee and asked to continue and extend its work to cover any structures and their operation that are connected with and serve purposes similar to boilers. The amount of time and work which the various members of this entire committee have given to the preparation of this report is so great that the Council wishes to record here its sincere appreciation.

Threads for Fixtures and Fittings. As the result of careful consideration of this subject and the coöperation by detailed correspondence with a selected list of thirty-eight of the largest manufacturers, the Committee on Threads for Fixtures and Fittings has completed its work on Rolled Threads. The report on Straight Threads will be presented at the Annual Meeting, 1915.

Tolerances for Screw Threads is a subject which is receiving the attention of a special committee and with the ready coöperation of manufacturers of taps and dies, the committee is now at work on tolerances for taps and screw threads.

The Power Test Report resulting in a complete standard for power tests is completed and presented for record in the Transactions for 1915. This is another example of years of self-sacrifice.

A permanent committee will be appointed to interpret the rules of the report when called upon to do so, to make such revisions as may be found desirable, and to modify the rules to meet new conditions as they may arise in the future. This new committee will hold meetings from time to time at which all interested will have opportunity to present suggestions.

RELATIONS WITH OTHER SOCIETIES

The American Institute of Electrical Engineers, the American Institute of Mining Engineers and The American Society of Mechanical Engineers, representing the Founder Societies of the United Engineering Society have coöperated by joint agreement in maintaining and financing the libraries of the Founder Societies under the direction of a Library Board. The same arrangement has also been provided in the matter of insurance and the establishment and maintenance of the Library Service Bureau. The representative appointed this year on the Board of Trustees is John R. Freeman, succeeding Fred J. Miller, whose term of office expired and who, under the by-laws, was not eligible for re-election; Jesse M. Smith and Alex. C. Humphreys, Past-Presidents are the other appointees.

The Engineering Foundation. A noteworthy incident in the history of the profession of engineering was the inauguration in January 1915 of The Engineering Foundation, a fund to be administered "for the advancement of arts and sciences connected with engineering and the benefit of mankind." The basis of this fund is the gift of $200,000 by Ambrose Swasey of Cleveland, Ohio, Past-President of this Society. The American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers and The American Society of Mechanical Engineers are equally represented in the administrative board of The Foundation. The United Engineering Society has been made custodian of the funds. The representatives of this Society on the Board are Jesse M. Smith and Alex. C. Humphreys; Frederick R. Hutton is Secretary of the Board.

Conference Committee. By the death of Alfred Noble a vacancy was caused in the Society's representation on the Joint Conference Committee of the national engineering societies and Arthur M. Greene, Jr., member of the Council, was appointed to fill the place. The Conference Committee is composed of two representatives each from the American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, The American Society of Mechanical Engineers and Society of Naval Architects and Marine Engineers.

John Fritz Medal Award. F. R. Hutton was reappointed for a term of four years on the John Fritz Medal Board of Award. The other representatives of the Society are Ambrose Swasey, J. A. Brashear and John R. Freeman.

Honorary Vice-Presidents. Frank B. Gilbreth represented the Society on the occasion of the opening of the new house of the Verein deutscher Ingenieure in Berlin. Major Wm. H. Wiley, Treasurer of the Society and member of the Council, was appointed the official representative of the Society at the convention of the Atlantic Deeper Waterways Association in Savannah, Georgia, F. F. Gaines acting as alternate.

As has been their practice for several years the Austrian Society of Engineers on the occasion of their annual meeting sent a letter of greeting to the Council.

The Engineers' Club of Kansas City, has been added to the list of those with whom we have arranged an exchange of courtesies in the use of the rooms and library privileges.

Graphics. As the result of invitations extended by The American Society of Mechanical Engineers a number of associations of national scope have appointed representatives on a committee to make a study of the methods used in the different fields of endeavor for presenting statistics and quantitative data in graphic form. Their preliminary report has been published for the purpose of inviting suggestions.

Classification of Literature of Applied Science. Delegates from about twenty national technical societies have conferred

with a view to perfecting a permanent organization for the purpose of preparing a classification of the literature of applied science which may be generally acceptable and adopted.

The name of this organization is Committee on Classification of Technical Literature. This Society is represented on the committee by F. R. Low, who is chairman of the committee of the whole, L. P. Breckenridge, W. W. Bird, A. E. Forstall, E. J. Prindle. The Committee from this Society will also take under consideration a proposed digest of material which has appeared in the publications of the Society, as the result of a suggestion from the New York Section on the occasion of a paper by E. J. Prindle on "A Proposed System of Classifying and Digesting the Records of the Society to render immediately available all information on each branch of every subject."

Expert Testimony. On request from and coöperating with the American Association for the Advancement of Science, the Council appointed F. H. Richards, W. H. Boehm, and H. deB. Parsons, with authority to add two members to their number, on a committee having for its object better practice in the use of expert testimony of engineers.

The American Society for Testing Materials have invited the Society to a proposed conference to consider the desirability and feasibility of coöperation in important matters of mutual interest and advantage to the various technical societies.

Flanges. A committee composed of H. G. Stott, *Chairman*, A. R. Baylis, A. M. Houser, Julian Kennedy, E. A. Stillman and W. M. White has been appointed to coöperate with the standardization committee of the Manufacturers' Association, in the recommendation of Flange Standards for Hydraulic Work.

The Committee on Flanges has been specifically requested to extend its work to include recommendations for ammonia apparatus and for steel fittings.

International Engineering Congress. The International Engineering Congress which was held in connection with the Panama-Pacific International Exposition in San Francisco was conducted under the auspices of the five national engineering societies, the American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, The American Society of Mechanical Engineers, the Society of Naval Architects and Marine Engineers, and was placed in the hands of a committee of management consisting of the presidents and secretaries of these five societies, and eighteen other members representative of them and resident in or near San Francisco.

Professor Durand and E. C. Jones later resigned from the Am.Soc.M.E. committee, and their places were filled by C. T. Hutchinson and E. C. Jones.

For the convenience of the members and their guests of the national engineering societies, an "Engineers' Special" was provided, leaving New York September 9, and arriving in San Francisco September 15.

Two hundred and forty-one papers were presented at the 52 sessions of the Congress, and although the existing international conditions made impossible a representative delegation from abroad, 66 of the papers contributed to the Congress were by authors outside of the United States. It is interesting to note that 48 authors of papers coming from the United States were members of this Society.

The return trip of a large number of the engineers was made along the line of the Southern Pacific and Canadian Pacific through Portland to Seattle, Victoria, Vancouver, Glacier, Lake Louise, Banff, Calgary and Moose Jaw, giving the party opportunity to inspect the engineering works along the line, the last objective being the big dam at Bassano.

MEETINGS

The Society has held its general meetings during the year, the Annual Meeting in New York and the Spring Meeting in Buffalo, N. Y.

An additional general meeting was held in San Francisco, September 16 and 17. The headquarters of the Society was the Clift Hotel and the local arrangements were in the hands of the local committee of the Society, F. W. Gay, *Chairman*, F. H. Varney, *Vice-Chairman*, C. F. Braun, *Secretary*, H. L. Terwilliger and J. T. Whittlesey. Five professional papers were presented. This meeting preceded the general sessions of the International Engineering Congress.

PUBLIC RELATIONS

The Council received an invitation from Worcester Polytechnic Institute to be represented at the fiftieth anniversary of the granting of the charter to Worcester Polytechnic Institute. Dr. Brashear, President, and Calvin W. Rice, Secretary, attended.

On invitation of the Governor of Massachusetts, E. F. Miller, I. E. Moultrop and John A. Stevens were appointed to represent the Society at the hearing on boiler legislation on December 17, 1915.

Park A. Dallis was appointed to represent the Society at the inauguration of Edward Kidder Graham as President of the University of North Carolina, and W. R. Dunn at the inauguration of John Henry MacCracken as President of Lafayette College.

Dr. Brashear and E. M. Herr were the representatives at the celebration of "Carnegie Day" at the Carnegie Institute of Technology.

Fire Hose Specifications. The Society coöperated with the Chamber of Commerce in the joint appointment of H. deB. Parsons as the representative of both organizations on a special committee created by the Fire Department of the City of New York to revise the specifications for fire hose. The work has been performed and the report placed in the files of the Society.

Sir William H. White Memorial. The movement recently started by the engineering societies of England to erect a memorial to the late Sir William H. White was responded to by the appointment of a memorial fund committee of this Society composed of Jesse M. Smith, *Chairman*, Alex. C. Humphreys and Frederick R. Hutton. The contribution from the members and friends of this Society was 63 guineas.

Constitutional Conventions. The Committee of Engineers representing national and local engineering societies was organized to present recommendations to the New York Constitutional Convention, and was composed of representatives of the American Society of Civil Engineers, American Institute of Electrical Engineers, The American Society of Mechanical Engineers, American Institute of Consulting Engineers, New York Section of the American Institute of Mining Engineers, Municipal Engineers of the City of New York, and the Brooklyn Engineers' Club. The Committee's recommendations were for continuity of control in the conduct of

the State's public works and by persons appointed by virtue of special fitness for these offices. In the report made by the joint committee the opinion is expressed that considerable success was secured by the engineers' efforts.

The general committee has presented its report and on recommendation of this committee and the representatives of this Society, Charles Whiting Baker, *Chairman,* A. M. Greene, Jr., E. G. Spilsbury, the committee is continued with those of the other societies represented for such assistance as it may render in other states where similar matters may be under consideration.

Naval Consulting Board. The Society was honored by an invitation from the Secretary of the Navy, Hon. Josephus Daniels, to participate in the work of the Naval Consulting Board, by the appointment of two representatives. By letter ballot W. L. R. Emmet and Spencer Miller were elected by the Council as the appointees of this Society. The Board is composed of two representatives each from twenty-two societies, including the Chairman, Thomas A. Edison, Honorary Member of this Society.

Engineer Reserve Corps. The suggestion was made in the spring of 1915 that the national engineering societies offer to assist the United States War Department in the formation of an Engineer Reserve Corps in the United States Army. Acting on this, the American Society of Civil Engineers, American Institute of Electrical Engineers, American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the American Institute of Consulting Engineers appointed committees authorized and directed to take such steps for the organization of such a reserve corps as might be advisable. In order to simplify future conferences a single committee has been formed to represent jointly the five societies—or the engineering profession as a whole. This general committee consists of Wm. Barclay Parsons, *Chairman,* Committee American Society of Civil Engineers; Henry S. Drinker, *Chairman,* Committee American Institute of Mining Engineers; B. J. Arnold, *Chairman,* Committee American Institute of Electrical Engineers; Wm. H. Wiley, *Chairman,* Committee The American Society of Mechanical Engineers; R. D. Mershon, *Chairman,* Committee American Institute of Consulting Engineers. The special committee in this Society is composed of Wm. H. Wiley, *Chairman,* John A. Hill, *Vice-Chairman,* W. F. M. Goss, H. A. Gillis and James M. Dodge. The separate committee in each society will take care of the work of its society as soon as the decision of the War Department can be given and a general scheme of organization adopted.

Pan-American Scientific Congress. In response to an invitation from the Department of State a committee of this Society is coöperating in the plans for a second Pan-American Scientific Congress to be held in Washington, D. C., December 27, 1915, to January 8, 1916. The Committee of this Society consists of General W. H. Bixby, *Chairman,* also Chairman in charge of Section V Engineering. Carl C. Thomas, Charles T. Plunkett, S. W. Stratton and Calvin W. Rice. Upon invitation from the Department of State, Ambrose Swasey, Past-President, and W. H. Marshall have been appointed as representatives of the Society to the Congress. Dr. John A. Brashear, President, has been selected by the Secretary of the Department of State of the United States as the representative of the engineering profession in America.

COUNCIL NOTES

December 7, 1915

At the meeting of the Council on December 7, 1915, the following members were present: John A. Brashear, *President,* M. L. Cooke, R. M. Dixon, *Chairman Finance Committee,* H. L. Gantt, W. F. M. Goss, A. M. Greene, Jr., James Hartness, Alex. C. Humphreys, E. E. Keller, Spencer Miller, H. G. Reist, J. E. Sague, Ambrose Swasey, Max Toltz, S. T. Wellman, E. H. Whitlock, Wm. H. Wiley, *Treasurer,* Calvin W. Rice, *Secretary,* and by invitation, Dr. D. S. Jacobus, *President-elect.*

The report of the Power Test Committee was received and ordered printed. It was voted to appoint a permanent committee to interpret, revise and modify the rules to meet new conditions as they arise.

It was voted to invite the Committee on Standardization of Flanges to extend the Flange Report to include flanged fittings for ammonia work.

It was voted unanimously to favor an amendment to the Constitution that will make the election of the Nominating Committee more democratic. Dr. Jacobus announced his intention to ask the Chairman of the Local Sections to assist him in the selection of the Nominating Committee.

The Administration Committee had reported at the previous meeting that the growth of the Society and the enlarged opportunities for the accomplishment of work of national importance presented new problems.

The Committee recommended the further development of the Sections and of The Journal as means for immediately strengthening the work of the Society and maintaining the organization in the influential position it should occupy in the world.

In order that the Secretary be free to devote himself to the larger features pertaining to the accomplishment of the Society's greater activities, and that the editors be released from attending to the manufacturing features of the Society's publications, the Committee recommended that they be relieved of the details of the business management of the Society, and these matters placed in the hands of a new department in charge of a business manager to be responsible for their execution.

The report of the Administration Committee was approved in principle and was referred to the Executive Committee with instructions to proceed with the development of its recommendations and from time to time recommend to the Council such action as it should take with reference thereto.

It was voted to approve a Local Section of the Society at Birmingham, Ala., and R. E. Brakeman was appointed Chairman, and Paul Wright, Secretary and Treasurer.

The report of the joint committee in connection with the drafting of amendments to the Constitution of the State of New York was received, and the Committee of the Society was ordered continued with similar committees of other societies to render assistance in other States where similar matters may be under consideration.

December 10, 1915

At the meeting of the Council on December 10, 1915, the new officers were formally introduced. The following members were present: John A. Brashear, *President,* J. H. Barr, R. M. Dixon, *Chairman Finance Committee,* W. F. M. Goss, Henry Hess, Alex. C. Humphreys, F. R. Hutton, D. S. Jacobus, *President-elect,* C. T. Main, Spencer Miller, H. de B

Parsons, J. E. Sague, J. A. Stevens, E. H. Whitlock, Wm. H. Wiley, *Treasurer*, and Calvin W. Rice, *Secretary*.

H. G. Stott was elected a member of the Board of Trustees of the United Engineering Society to succeed Jesse M. Smith, whose term of office had expired and who was not eligible for reëlection.

Prof. Frederick R. Hutton was reappointed to succeed himself as a representative of the Society on the John Fritz Medal Board of Award, to serve for a term of four years.

W. F. M. Goss was nominated as the representative of the Society to the Board of the Engineering Foundation.

P. N. Engel, Fred Dorner and Wynn Meredith were approved as Chairmen of the Chicago, Milwaukee and San Francisco Sub-committees on Increase of Membership, respectively.

Interpretations of the Boiler Code were on motion received and ordered issued. These are published elsewhere in this issue of The Journal.

It was voted that the request to the Committee on Standardization of Flanges to extend their work to flanged fittings for ammonia apparatus include a further request to consider steel fittings.

It was voted that the Committee on Constitution and By-laws be requested to report the phraseology of suitable By-laws to cover the duties, manner of appointment as to terms of office, etc., of all the Standing Committees of the Society for which instructions have not already been provided.

Calvin W. Rice, *Secretary*.

NEW OFFICERS OF THE SOCIETY

DAVID SCHENCK JACOBUS

President for 1916

David Schenck Jacobus, distinguished as one of the foremost American mechanical engineers and educators, was born in Ridgefield, N. J., in 1862. He was educated in a private school, then in Stevens High School, Hoboken, N. J., where he won by competitive examination a free scholarship in the Stevens Institute of Technology. He was graduated from the Institute with the degree of Mechanical Engineer in 1884.

Upon his graduation he was appointed instructor, then assistant professor of experimental mechanics, being closely associated with Prof. J. E. Denton. In 1897, he was called to the chair of experimental mechanics and engineering physics, in which he continued until 1906. From 1900 to 1906 he was also in charge of the Carnegie Laboratory of Engineering, built and equipped with funds donated by Andrew Carnegie for carrying out a course of instruction to supplement class room work by practical experiments made by the students.

At the Stevens Institute, Dr. Jacobus devised original apparatus for illustrating physical laws, and for testing various mechanical devices, and developed a course of experimental mechanics especially fitted for a mechanical engineering school.

While at the Institute, too, Dr. Jacobus performed a large amount of expert work, involving investigations and reports upon mechanical devices and processes for the production of power, and efficiency tests on steam motors, turbines and other power plant apparatus. He was early in the field of refrigeration, making tests of machines and writing articles on the subject. He also made early experiments on acetylene gas generators and on fire sprinkler systems.

Since 1906, he has been actively associated with the Babcock & Wilcox Company at the head of its engineering department in the position of advisory engineer. This made it necessary for him to give up practically all his work at Stevens Institute, although it was arranged that he should continue on the faculty under the title of special lecturer in experimental engineering and should deliver lectures on steam engineering subjects. At the same time, as an evidence of esteem, the Institute conferred upon him the honorary degree of Doctor of Engineering and he was made a trustee.

Dr. Jacobus is an authority on steam engineering, and he has written numerous scientific papers on steam engineering subjects, many of which have been included in the transactions of the engineering societies and many published in engineering periodicals.

He was elected to membership in The American Society of Mechanical Engineers in 1889; he was a Manager of the Society from 1900 to 1903 and was Vice-President from 1903 to 1905. He has served on a number of committees of the Society, among which was the committee which framed the present constitution. He was chairman of the committee appointed to standardize a system for testing steam engines which presented its final report in December, 1902. In 1903, he was appointed chairman of a committee to suggest a standard tonnage basis for refrigeration; this committee reported in 1904, and was re-appointed. He has served on the Committee on Power Tests which originally organized by electing him as chairman; owing to pressure of business duties he resigned the chairmanship, but he has nevertheless taken an active part in the preparation of the report. In 1914, he was appointed a member of an advisory committee which was formed to assist the Boiler Code Committee, and on the combining of the Boiler Code Committee and advisory committee into a single Boiler Code Committee he was made one of the members. He was elected President of the Society in December, 1915.

He is a member of the American Institute of Mining Engineers, American Institute of Electrical Engineers and the Society of Naval Architects and Marine Engineers, and a fellow of the American Association for the Advancement of Science. He was President of the American Society of Refrigerating Engineers in 1906-1907. He is a member of the American Mathematical Society, the Society for the Promotion of Engineering Education, the American Society for Testing Materials, and The Franklin Institute of the State of Pennsylvania.

J. SELLERS BANCROFT

J. Sellers Bancroft was born in Providence, R. I., in 1843. He was educated in Philadelphia, and was graduated from the Public High School there in 1861. On February 1 of the same year, he began an apprenticeship with the successors of Bancroft and Sellers, William Sellers & Co., whose work has contributed so much to the American machine tool industry. The firm of Bancroft & Sellers was founded by his father and Coleman Sellers in 1848. Mr. Bancroft became gang foreman in 1863, shop foreman in 1866, and was admitted to the firm in 1873. Finally, when the business was incorporated in 1887, he was appointed general manager.

He remained with this concern until January 31, 1902, when his prior successful activities in directing the development of the manufacture of the Lanston type-setting machine induced him to take the position of general manager and mechanical engineer of the Lanston Monotype Machine Company, of Philadelphia. He still holds this position, and, in addition, those of treasurer, director and vice-president of the company.

Mr. Bancroft has been a prolific inventor, as is attested by the large number of patents—more than one hundred—which have been granted him. These cover improvements in machine tools, injectors, shafting appliances, power cranes, and the interlocking electric devices for their control; and type-casting and composing machines.

Since 1897, he has been engaged in the improvement of the monotype casting and composing machine, which he has brought into practical working shape, and which is now being introduced all over the world. The gradual development by him of this machine can be traced in the improvements of it he has from time to time patented.

Mr. Bancroft's membership in the Society dates back to practically the time of its organization, and his name appears in the second year book issued in January 1881. He has been a member of The Franklin Institute of the State of Pennsylvania since the early 60's. He is a member of the Society of Naval Architects and Marine Engineers.

JULIAN KENNEDY

Julian Kennedy, expert in iron and steel manufacture, was born in Poland, Ohio, in 1852. He began his education in the public school and in the Poland Union Seminary. He left this institution in 1869 to become a draftsman, under his father's supervision, on the construction of the Struthers Iron Company's blast furnace, at Struthers, Ohio, and then a machinery attendant.

In 1872, he entered the Sheffield Scientific School of Yale College, and was graduated three years later. He took a course in civil engineering until the end of the junior year and then continued in the course in chemistry. After graduation, he was appointed instructor in physics, and remained at the School in this capacity for one year, taking at the same time a post-graduate course in the chemistry of iron and steel, and also a special course in higher mathematics and astronomy. During this time, he had charge of the physical laboratory, gave a course of illustrated lectures on physics to the students of several seminaries in New Haven, and also lectured in the mechanics course of the School.

In 1876 Mr. Kennedy was appointed superintendent of blast furnaces of the Brier Hill Company, Youngstown, Ohio. The next year, he became superintendent of the blast furnace of the Struthers Iron Company, and in the following years he served successively as superintendent of the Morse Bridge Works, Youngstown, Ohio; superintendent of blast furnaces at the Edgar Thompson Steel Works, Braddock, Pa.; superintendent of the Lucy Furnaces, Pittsburgh, Pa.; and general superintendent for Messrs. Carnegie, Phipps and Co., with headquarters at Homestead, Pa. In all these works, he was responsible for both construction and operation.

In 1888, he was appointed chief engineer of the Latrobe Steel Works, Latrobe, Pa. He had charge of the construction of this works, and in 1890, while continuing as chief engineer of the plant, opened an office for private practice in Pittsburgh. Since that time, he has been engaged in general consulting and contracting engineering business and has been retained as consulting engineer by practically every important steel works in the United States. He has also performed a great deal of engineering work in several European countries.

Mr. Kennedy has taken out a large number of patents in connection with the manufacture of iron and steel, and has also acted as expert in a large number of patent suits. Among his own inventions, most of which are in successful use, are improvements in blowing engines, reversing engines, blooming mills, hot blast stoves, blast furnace filling devices and other steel works equipment.

Mr. Kennedy is a member of the Engineers Society of Pennsylvania, the American Institute of Mining Engineers, the British Iron and Steel Institute, the New York Chamber of Commerce, and the Pittsburgh Chamber of Commerce.

He received the honorary degree of Master of Arts from the Sheffield Scientific School in 1900, and in 1909, Stevens Institute of Technology conferred on him the honorary degree of Doctor of Engineering.

He was elected to membership in the Society in 1912 and was appointed on its sub-committee on Iron and Steel in 1913.

JOHN H. BARR

John Henry Barr, mechanical engineer, was born at Terre Haute, Ind., in 1861. He was educated at the University of Minnesota, receiving the degrees of Bachelor of Mechanical Engineering in 1883 and Master of Science five years later. From Cornell University, he obtained the degree of Master of Mechanical Engineering in 1889.

Mr. Barr began his professional training in 1883, when he was appointed assistant to the resident mechanical engineer of the Calumet and Hecla Mining Company. The following year, he was appointed mechanical engineer of the Lake Superior Iron Works. In 1885, he began his work as a teacher, being appointed instructor in mechanical engineering at the University of Minnesota; four years later he was made assistant professor and in 1890 full professor. From 1891, for four years, he was assistant professor of mechanical engineering at Sibley College, Cornell University. Here also he rose to be associate professor of machine design and later full professor of machine design, which chair he occupied from 1898 to 1903. In 1900 he was mechanical engineer to the Anaconda Copper Mining Co. From 1903 to 1908 he was director and factory manager of the Smith Premier Typewriter Co. From 1909 to 1913 he was consulting engineer of the Union Typewriter Co., and in 1913 he was appointed chief engineer of the Remington Typewriter Co.

Mr. Barr was elected to membership in the Society in 1889. He was appointed on the Committee on Meetings in 1913 and served as chairman in 1915. He acted on the Nominating Committee in 1914, and is chairman of the Sub-Committee on Protection of Industrial Workers.

He is a fellow of the American Association for the Advancement of Science and a member of The Franklin Institute. He was a trustee of Cornell University for ten years. He was president of the Syracuse Chamber of Commerce, 1910-11, and was a member of the Syracuse Intercepting Sewerage Board till after his removal from Syracuse. He was a member of the Syracuse Lighting Commission (1907). He was a member of the New York State Commission on Voting Machines from 1903 to 1915 (chairman 1907-1915).

He is the author of a number of textbooks and articles on machine design. His textbooks include Kinematics of Machinery, Notes on Machine Design, and (with D. S. Kimball) Elements of Machine Design. He was the author of reports on Machine Tools at the Paris Exposition, 1899.

JOHN A. STEVENS

John A. Stevens, consulting mechanical engineer, was born at Galva, Illinois, in 1868. He was graduated from the East Saginaw High School and studied one year at the University of Michigan. He served a three years' apprenticeship to the machinists' trade with Mitts and Merrill, Saginaw, Mich., after which he was engineer on the lake steamers Sappho, Byron Whitaker, W. H. Stevens, Roman and Cambria. At the age of twenty-seven he was granted an unlimited engineer's license for ocean steamships.

In 1893 he came East to enter the employ of the International Navigation Company of New York, and he served as engineer on board their ships Indiana, Illinois, New York, St. Louis and St. Paul. On the last of these he was first assistant engineer, having been given eight promotions in two years and eight months.

He resigned from the company's service in 1896 to take up the position of chief engineer with the Merrimack Manufacturing Company, Lowell, Mass. While with this company, he practically rebuilt its entire steam plant and also superintended the power work of the company's southern mills. He made numerous complete tests of steam plants and boiler trials of engines and auxiliaries. Since the date of his severing his connection with this company, he has made all its power plant layouts and estimates.

He resigned his position as chief engineer at the Merrimack Manufacturing Company early in 1909, and in May of the same year he went into private general consulting engineering practice. Since that time he has superintended the construction of a great many power plants, made complete analyses of many large properties, and dealt with various engineering problems.

Mr. Stevens has been granted a number of patents for water tube steam boilers, and is also the patentee of the American steam superheater.

He was elected to membership in The American Society of Mechanical Engineers in 1902, and in the Society of Naval Architects and Marine Engineers in the same year. In 1907 he was elected a member of the National Association of Cotton Manufacturers.

He was appointed by Governor Guild in 1907 to represent the boiler using interests of Massachusetts on the Massachusetts Board of Boiler Rules. He served on the Board for three years, at the expiration of which time he was appointed by Governor Draper to serve another similar term. The first three years of his service on this Board were spent in formulating the Massachusetts Rules, which were later used in many other states and cities.

Mr. Stevens was one of the seven members originally selected to serve on the Society's committee "to formulate standard specifications for the construction of steam boilers and other pressure vessels and for the care of same in service," now known as the Boiler Code Committee, and he has served actively on this committee continuously since its organization in 1911.

H. DEB. PARSONS

Harry de Berkeley Parsons, consulting engineer, was born in New York City in 1862. He was educated at Columbia College, from which he was graduated as Bachelor of Science in 1882, and at Stevens Institute of Technology, from which he received the degree of Mechanical Engineer, two years later. From 1892 to 1907 he was professor of steam engineering at Rensselaer Polytechnic Institute, and in 1908 he was appointed professor emeritus of practical engineering.

Mr. Parsons has been practicing his profession as consulting engineer in New York since 1885. He was a member of the New York State Voting Machine Commission from 1898 until 1915, and of the Metropolitan Sewerage Commission of New York from 1908 until 1914, when the work of designing a main drainage system for all the boroughs of the City was completed, together with a report showing the need for such system. He has served as consulting engineer for many of the city departments and for the Board of Estimate and Apportionment, as well as for many private firms, banks and corporations, and has been retained for making numerous appraisals of industrial establishments.

He is the author of "Steam Boilers, Their Theory and Design" and of "Disposal of Municipal Refuse."

Mr. Parsons was elected to membership in The American Society of Mechanical Engineers in 1885. He served on the Publication Committee from 1890 to 1902. He was elected on the Meetings Committee in 1903, and also served on this Committee from 1909 to 1914. He acted as chairman of the representatives of the Society on the Joint Committee on Fire Proofing Tests, whose report was published in Volume 18 of The Transactions. He was chairman of the Committee on Standard Cross-Sections and Symbols, whose report was published in Volume 36 of The Transactions.

He is a member of the American Society of Civil Engineers, the Society of Naval Architects and Marine Engineers, the Chamber of Commerce and the Merchants Association of New York.

FELLOWSHIPS AT ILLINOIS

The University of Illinois announces fourteen research fellowships in the Engineering Experiment Station, open to graduates of American and foreign universities and technical schools. Appointments are made for two years and lead to a Master's degree. Nominations to fellowships are made from applications received by the Director of the Engineering Experiment Station; they are based on character, scholastic attainments and promise of success.

The fellowships afford an excellent opportunity for the carrying on of investigations in the various branches of engineering and for the study of problems of importance to engineers and to manufacturing and industrial interests.

Those desiring additional information should address the Director of the Station at the University.

CRIPPLED SOLDIERS PROBLEM

Frank B. Gilbreth, Mem.Am.Soc.M.E., the author of the paper on Motion Study for the Crippled Soldier, published in the December, 1915, issue of The Journal, writes that he is still open to receive information regarding cases in this country in which maimed or otherwise disabled men have been educated and assisted to perform work successfully. Mr. Gilbreth's address is 77 Brown St., Providence, R. I.

Mr. Gilbreth himself has been taking active steps to obtain such information for the purpose of applying it to the problem of disabled soldiers, and his efforts have met with success, but he still needs more data on account of the complexity of the problem.

He reports valuable assistance from Prof. L. M. Wallace of Purdue University, who sent out the following questionnaire to members of the University staff, with good results: Would you kindly indicate the occupations in which you have known disabled men to have found successful employment, and the special devices they may have used to aid them in their work?

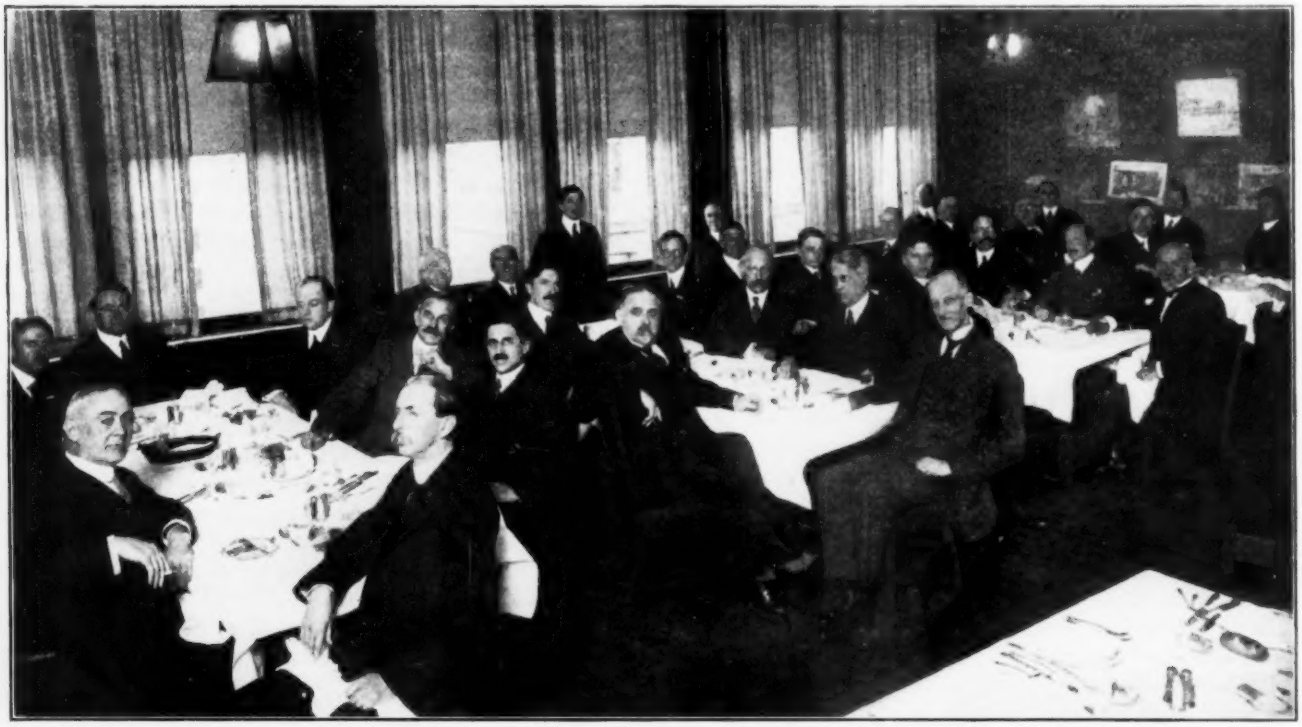
CONFERENCE OF LOCAL SECTIONS

The Conference of delegates from the Local Sections of the Society held at the Annual Meeting proved a great success and the results thereof promise much toward the future success and development of the Society. The Chairman or Secretary of each of the fourteen Sections was present and in addition there were delegates from the Providence Association of Mechanical Engineers, which is affiliated with The American Society of Mechanical Engineers, and from several industrial centers where the members of the Society anticipate the formation of Sections.

The delegates and members of the Committee on Sections in attendance were Elliott H. Whitlock, Chairman; W. F. M. Goss, L. C. Marburg and Walter Rautenstrauch, of the Committee on Local Sections (D. Robert Yarnall, the fifth member of the Committee, was absent owing to serious illness); Park A. Dallis, Secretary, Atlanta Section; H. N. Dawes, Chairman, and W. G. Snow, Secretary, Boston Section; David Bell, Chairman, Buffalo Section; H. M. Montgomery, Chairman, Chicago Section; J. T. Faig, Secretary, Cincinnati Section; W. W. Smith, Chairman, Los Angeles Section; L. E. Strothman, Chairman, Milwaukee Section; W. H. Kavanaugh, Chairman, Minnesota Section; E. H. Lockwood, Secretary, New Haven Section; Edward Van Winkle, Chairman, and H. R. Cobleigh, Treasurer, New York Section; R. H. Fernald, Chairman, Philadelphia Section; C. F. Braun, Secretary, San Francisco Section; Edward Flad, Chairman, St. Louis Section; P. B. Morgan, Chairman, Worcester Section; A. H. Annan, Vice-President, and J. A. Brooks, Secretary of the Providence Association of Mechanical Engineers.

Others present during the Conference were I. E. Moultrop, Boston, Chairman of the Committee on Increase of Membership; Max Toltz, member of the Council and of the Minnesota Section; A. L. Williston, Boston Section, and A. M. Greene, Jr., Troy, N. Y., member of the Council.

Three business sessions were held, each being preceded by a luncheon of the delegates and the officers of the Society. At these luncheons, the delegates had opportunity to become better acquainted with one another and with the members of the Council, Past-President James Hartness, President John A. Brashear, President-Elect D. S. Jacobus, Secretary C. W. Rice, Vice-Presidents H. L. Gantt, New York, E. E. Keller, Detroit, and H. G. Reist, Schenectady; also M. E. Cooley, Ann Arbor; W. H. Carrier, Buffalo; H. H. Esselstyn, Detroit; Lee C. Moore, Pittsburgh; J. V. V. Colwell, New York; T. C. McBride, Philadelphia; L. D. Burlingame, Providence; P. A. Poppenhusen, Chicago, and F. E. Bausch, St. Louis.



Conference Luncheon of Delegates from the Local Sections of the Society

These luncheons were held each day of the Annual Meeting and all Local Sections were represented. Those present at the first luncheon, reading from the head of each table and in a clockwise direction, were:

FIRST TABLE	SECOND TABLE	THIRD TABLE	FOURTH TABLE
James Hartness	D. S. Jacobus	John A. Brashear	Paul P. Morgan
Edward Flad	H. M. Montgomery	John T. Faig	H. L. Gantt
E. H. Lockwood	C. W. Obert	J. T. Whittlesey	Carl F. Braun
L. C. Marburg	M. E. Cooley	Park A. Dallis	Calvin W. Rice
W. H. Kavanaugh	W. F. M. Goss	E. H. Whitlock	Robert H. Fernald
Max Toltz	Ernest Hartford	W. W. Smith	E. E. Keller
L. G. French	J. A. Brooks	H. G. Reist	I. E. Moultrop
	Alex. C. Humphreys	H. H. Dawes	Arthur H. Annan
	Louis E. Strothman		

It was the consensus of opinion that the development of Sections is one of the vital needs of the Society, and that regular meetings should be held in every locality where there are sufficient members to insure success.

At future Annual Meetings, it is planned to continue this feature of a Conference of Local Sections as part of the program, and the opportunity given to members in all parts of the country to be brought into close contact through their duly elected delegates with the officers of the Society and its activities cannot fail to promote the best interests of the Society.

JOHN FRITZ MEDAL AWARD

The John Fritz Medal, awarded annually for notable scientific or industrial achievement, was in 1915 awarded to Dr. James Douglas, eminent mining engineer, for "notable achievements in mining, metallurgy, education and industrial welfare."

It was originally planned to present the medal to Dr. Douglas at the International Engineering Congress in September, 1915, but his health did not permit of his taking the journey to San Francisco. Accordingly, on December 5, 1915, the medal was handed him at his home at Spuyten Duyvil by Dr. Albert R. Ledoux, Past-President of the American Institute of Mining Engineers.

James Douglas was born at Quebec, Canada, in 1837. He entered the University of Edinburgh in 1885 and studied there for two years. Returning to Canada he graduated from Queens University, Kingston, Ontario, with the degree of Bachelor of Arts, having also studied medicine and later theology. After his graduation he traveled extensively in Europe and in the Orient, and then returned to Edinburgh where he continued his course in medicine.

At this time his father's gold and copper mine investments in Canada were in jeopardy because, while the mines contained considerable 2 per cent copper ore, there was no satisfactory process for its economical extraction. He abandoned his studies and teaching and went into the mining field to endeavor to rehabilitate his father's interests; and in association with Dr. Hunt he worked out the well-known Hunt and Douglas process for the extraction of copper.

He came to the United States in 1875, being employed to apply this process to the product of the Jones mine in Berks County, Pa., as superintendent of the Chemical Copper Co. at Phoenixville. The plant was afterwards destroyed by fire and Dr. Douglas was for a time without fixed employment, although he did some professional work in mining and metallurgy. He made several visits to Butte, Mont., and it has been said that he was the first to predict the secondary enrichment in this area.

Through William E. Dodge, he was brought into contact with the old metal house of Phelps, Dodge & Co. When this firm took over the Copper Queen mine, the management was placed in his hands and he was given an interest in the concern. Later, upon the incorporation of the firm, Dr. Douglas became its president. Under his active management the most modern devices have been adopted in the company's mills and smelteries, and the mines and railroads controlled by it have been very profitable.

During his years of active business life, busy with invention and adaptation of processes, and with expansion and consolidation, Dr. Douglas has found time to make numerous contributions to the literature of mining and of general science, and many of his papers and articles have appeared in the transactions of various technical and other societies. In addition, he has published four historical volumes, including the journal and reminiscences of the life of his father, James Douglas, M.D.

Both Queen's University and McGill University have conferred on him the honorary degree of LL.D. He has been twice President of the American Institute of Mining Engineers. He has been the recipient of the gold medal of the Institution of Mining and Metallurgy.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED FOR ON FEBRUARY 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The Candidates will be balloted upon by the Council unless objection is received by February 10, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

BROWN, BENJAMIN F., Pres. and Mgr., The Brown Bag Filling Mch. Co.,	Fitchburg, Mass.
COOKSON, THOMAS J., Pres., The Cookson Steam Specialty Co.,	Cincinnati, Ohio
CUMMINGS, HENRY H., Pres., Cummings Mch. Wks.,	Boston, Mass.
DODSON, CLARENCE F., Supt. of Wks., Irving Iron Wks.,	Long Is. City, N. Y.
EVERETT, CHARLES J., Treas., Revolute Mch. Co.,	New York
FRENCH, DAVID W., Supt., Hackensack Water Co.,	Weehawken, N. J.
FREYSINGER, JOHN B., Ch. Draftsman, Winchester Repeating Arms Co.,	New Haven, Conn.
GUTHRIE, JAMES, Auto. Engr., Briscoe Freres,	Jackson, Mich.
HILE, CHARLES H., Ch. of Maintenance, Boston Elev. Rwy. Co.,	Boston, Mass.
HILL, B. HOUSTON, Pres., Steam Equipment Mfg. Co.,	Pittsburgh, Pa.
JONES, WILLIAM T., Engr., Cons. Engrg. Co.,	Boston, Mass.
KAUPERT, RICHARD, Master Mech., Douglas Co.,	Cedar Rapids, Ia.
KENNEY, WILLIAM J., Ch. Engr., The Under-Feed Stoker Co. of America,	Chicago, Ill.
KIHN, JULIUS J., Supt., R. Hoe & Co.,	New York
LANHAM, EDWIN J.,	Franklin, Pa.
LARSEN, CHARLES, Mech. Engr., M. J. O. Fallon Supply Co.,	Denver, Colo.
LOCKWOOD, J. B. C., Cons. Engr.,	Portland, Ore.
LUNDQUIST, WILHELM E., Ch. Draftsman, The Edison Elec. Ill. Co.,	Boston, Mass.
MCGREW, JOHN A., Supt., Saratoga & Champlain Div., Delaware & Hudson Co.,	Albany, N. Y.
MAHY, ARTHUR H., Ch. Engr. and Supt., North Adams Gas & Elec. Lgt. Co.,	No. Adams, Mass.
MEYER, JULIUS M., Partner, Vaughn, Meyer & Sweet, Cons. Engrs.,	Milwaukee, Wis.
MOODY, V. D., Cons. Engr., Moody Engrg. Co.,	New York
MULLINER, RICHARD H., Mgr. and Part Owner, Mulliner-Enlund Co.,	Syracuse, N. Y.

Newhall, Henry B., Jr., Vice-Pres., N. J. Fdy. & Mchy. Co., and Newhall Chain Forge & Iron Co., New York
Nilson, Lars G., Pres. and Ch. Engr., Nilson-Miller Co., Hoboken, N. J.
Rhoads, Joseph E., Mem. of Firm, J. E. Rhoads & Sons, Wilmington, Del.
Roberts, Odin, With Roberts & Cushman, Boston, Mass.
Ross, John A., Jr., Prof. of Mech. Engrg., Clarkson College of Tech., Potsdam, N. Y.
Schafer, W. H., Mech. Engr., The Cincinnati Bickford Tool Co., Oakley, Cincinnati, O.
Sheldon, Arthur N., Mem. Firm, F. P. Sheldon & Son, Engrs. and Arch., Providence, R. I.
Sperling, Nathaniel J., Supt. Mech. Dept., Astoria Light, Heat & Pwr. Co., Astoria, L. I., N. Y.
Streiff, Abraham, Engr., Fargo Engrg. Co., Jackson, Mich.
Valentine, Warren R., Supt., Shop No. 2, Pittsburgh Plate Glass Co., Ford City, Pa.
Wallace, John D., Mfg. Engineer, Chicago, Ill.
Wason, Leonard C., Pres., Aberthaw Constr. Co., Boston, Mass.
Welles, Edward R., In charge Mech. Engrg. Dept., The J. G. White Engrg. Corp., New York
Wintroath, John A., Mech. Supt., Layne & Bowler Corp., Los Angeles, Cal.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bancroft, George H., Tech. Asst. to Ch. Engr., Steere Engrg. Co., Detroit, Mich.
Baum, I. Albert, Engr.-in-charge, Martin Free Bridge, Camden, Ark.
Benster, Lucien H., with Moline Scale Co., East Moline, Ill.
Cameron, James S., Supt. of Plant, Northern Elec. Co., Ltd., Montreal, Canada
Dempsey, Michael J., with Chase Metal Works, Waterbury, Conn.
Dixon, Wallace C., Draftsman, Hopkins & Allen Arms Co., Norwich, Conn.
Dolan, George F., Inspector, Panama Canal, Washington, D. C.
Farrington, Thayer B., Genl. Foreman, Louisville Div., Southwest System, Penn Lines West, Louisville, Ky.
Jenner, Otto G., Indus. Engr., Inland Steel Co., Chicago Heights Wks., Chicago, Ill.
Lockwood, Harold R., Supt. of Eng. Dept., Douglas Robinson Charles S. Brown Co., New York
Porter, Robert, Engr. and Mgr., New England Branch, Diamond Pwr. Specialty Co., Detroit, Mich.
Schmidt, John D., Asst. Engr., The Natl. Sugar Refinery, Yonkers, N. Y.
Sihra, Nand S., Touring, Visiting manufacturing and engineering plants, Stockton, Cal.
Snyder, Frederick W., Instr. of Mchy., Williamson Free Sch. of Mech. Trades, Williamson School, Del. Co., Pa.
Tiechman, Henry F., Engr. Draftsman, Lukens Iron & Steel Co., Coatesville, Pa.
Tulloss, Joseph C., Ch. Engr., Fire & Accident Prevention Co., Baltimore, Md.
Ycasiano-Roxas, Francisco, Mech. and Testing Engr., Bureau of Science, Dept. of Int., Govt. of Philippine Is., Manila, P. I.

FOR CONSIDERATION AS JUNIOR

Ackerman, Henry C., Asst. Master Mech., Hercules Pwdr. Co., Kenvil, N. J.
Allen, Clifton H., Mech. Engr., The Walker Mfg. Co., Denver, Colo.
Billmyer, Carroll D., Draftsman, Off. of Asst. to Pres., Norfolk & Western Rwy. Co., Roanoke, Va.
Buenger, Albert, Heating & Ventilating Engr., with W. L. Steele, Sioux City, Ia.
Buford, Edwin H., Engr. of Design and Erection, Monsanto Chemical Wks., St. Louis, Mo.
Edwards, Henry H., Mech. Engr., The Bantam Anti-Friction Co., Bantam, Conn.
Garrison, Wyckoff L., with The Babcock & Wilcox Co., Bayonne, N. J.
Kunz, William J., Mech. Engr., Otis Elev. Co., Yonkers, N. Y.
Miller, Ernest P., Jr., Indus. Management, Cheney Bros., So. Manchester, Conn.
Moul, Harry A., Asst. to Wks. Mgr., Amer. Steel Foundries, Indiana Harbor, Ind.
Nofsinger, Lewis E., 1st Asst. in Mch. Shop Practice, Kansas City Poly. Inst., Kansas City, Mo.
Schulte, Max J. L., Engrg. Dept., Combus. Engrg. Corp., New York
Sparkes, John G., Mech. Engr., Patent Law Off., R. D. Johnston, Jr., Atty., Birmingham, Ala.
Taylor, Paul H., Mech. Engr., H. French & A. Hubbard, Boston, Mass.
Thomas, Winthrop G., Circuit Lab., Western Elec. Co., New York
Willson, Hubert E., Steam Expert, Joliet Wks., Illinois Steel Co., Joliet, Ill.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Barnum, Starr H., 2nd., Secy., The Bigelow Co., New Haven, Conn.
Benner, Henry L., Secy. and Treas., Amer. Insulating Mchy. Co., Philadelphia, Pa.
Crute, William R., Engr. Elec. Pwr. House, Norfolk & Western Rwy., Pocahontas, Va.
Freeman, Frederick C., Constr. Dept., The United Gas Improvement Co., Philadelphia, Pa.
Hoffman, Roscoe C., Mech. Engr., Sun Motor Car Co., Buffalo, N. Y.
Hood, Warren B., Shop Engr., Angus Shops, Canadian Pacific Rwy. Co., Montreal, Canada
Knoop, Theodore M., N. Y. Mgr., Epping-Carpenter Pump Co., New York
Kremers, Clarence H., Constr. Engr., Mammoth Copper Mining Co., Kennett, Cal.
Loutrel, Cyrus H., Factory Mgr., Natl. Lock Washer Co. Newark, N. J.
Peterson, Eric H. A., Ch. Draftsman & Mech. Engr., The Hutteman & Cramer Co., Detroit, Mich.
Turno, Walter G. W., Engr. and Estimator, Johns-Manville Co., New York

SUMMARY

New Applications	71
Applications for change of grading:	
Promotion from Junior	11
Total	82

NEW MEMBERS

Hereafter there will be published each month a summary giving data regarding the current ballot for new members, as to the type of positions held, the average age of those being considered by the Council for each grade, and the number who are college graduates.

Beginning with the February issue a list will be published of those new members who qualify each month, so that hereafter it will not be necessary for the members to wait until the new Year Book is published to discover those who have been added to the Society's rolls during the year.

This additional information will undoubtedly be of particular interest to the membership and testify to the excellent character and high standing of those joining the Society under the present strict requirements.

PERSONALS

George L. Clouser has accepted a position with the Baldwin Locomotive Works, Philadelphia, Pa., as draftsman. He was until recently associated with the motive power department of the Philadelphia and Reading Railroad, Reading, Pa.

Cornelius J. Allaart has become affiliated with the engineering department of the Curtiss Motor Company of Buffalo, N. Y.

Julius G. Hatman, formerly associated with the R. H. Beaumont Company, Philadelphia, Pa., has accepted the position of efficiency engineer with the Semet-Solvay Company, Ensley, Ala.

George P. Sonn has resigned his position with the Chase Metal Works, Waterbury, Conn., to accept a position with the engineering department of the Bridgeport Brass Company of Bridgeport, Conn.

Charles L. Samson has become affiliated with The Amalgamated Machinery Corporation of Chicago, Ill.

Clarence J. Harter has become associated with the Pratt and Whitney Company of Hartford, Conn., in the capacity of mechanical engineer. He was until recently in the employ of the Remington Arms Union Metallic Cartridge Company, Bridgeport, Conn., as technical adviser to the purchasing department.

Courtney N. Mitchell has severed his connections with the Chandler Motor Car Company, Cleveland, O., and is now employed as chief engineer of The Eclipse Motor Company, Cleveland, O.

Frederick A. Krehbiel, president of the Krehbiel Company, engineers and constructors, Chicago, Ill., announces that he has secured as a partner Edward N. Lake, formerly in charge of the Chicago office of the Stone and Webster Engineering Corporation. The business will be continued under the present firm name, with Mr. Lake as treasurer and manager and Mr. Krehbiel continuing as president.

J. N. Caughell, formerly connected with Dodge Brothers of Detroit, Mich., as chief engineer of power plant, has accepted the position of mechanical superintendent of the United States Department of Agriculture, Washington, D. C.

Morris A Hall, until recently managing editor of Motor Life, New York, is now connected with the advertising department of The Locomobile Company of America, Bridgeport, Conn.

Charles E. Paul, professor of mechanics at Armour Institute, Chicago, has been retained as consulting engineer by the National Lumber Manufacturers' Association.

William A. Cattell, consulting engineer of San Francisco, who filled the office of secretary-treasurer of the International Engineering Congress, has been retained by the Honolulu Rapid Transit and Land Company as a witness in the injunction suit brought by the Territory of Hawaii against that company. He will investigate the plant of the company and testify as to the physical valuation and cost of its property.

Elliott H. Whitlock, Manager, Am.Soc.M.E., consulting engineer, has been appointed general superintendent of the Sandusky Portland Cement Company, with headquarters in Cleveland. Mr. Whitlock was formerly associated with the National Carbon Company.

H. P. Camp, for the past few years associated with the Union Metallic Cartridge Company, Bridgeport, Conn., has resigned to accept a position as efficiency engineer with the Western Cartridge Company, Alton, Ill.

A brief article on a Novel Combination Locomotive by E. C. DeWolfe appears in the December 4 issue of Coal Age.

Nathan C. Johnson contributed the first of three articles on the making of better concrete to the December 4 issue of Engineering Record. This article, entitled Materials vs. Methods—Testimony of Moving Pictures in the Study of Concrete, deals with mixing, suggests necessary function of a concrete mixer and points out the evil of the short mixing period. The second article, which appears in the December 11 issue, deals with abuses common in the handling of sloppy wet mixtures, and the last article, published December 18, contains analytical studies made in regard to the placing of concrete by methods in present vogue and the effect such methods have upon the quality and durability of concrete.

V. W. Zilen is the author of a series of articles on Design of Steel Passenger Equipment, now appearing in the Mechanical Edition of the Railway Age Gazette. The first part is published in the September issue and will be continued after January 1 in the Railway Mechanical Engineer, which is the new title for the Mechanical Edition of the Railway Age Gazette.

John R. Freeman, Past-President, Am.Soc.M.E., and Prof. Rolla C. Carpenter are among the ten eminent engineers, geologists and scientists who have been designated to go to the Isthmus of Panama to investigate the entire subject of the slides on the Panama Canal and to submit a report to the President thereon. Mr. Freeman is a specialist in hydraulics and was consulting engineer for the Isthmian Canal dams and locks from 1907 to 1909 and is consulting engineer to the Canadian Government on water power conservation. Professor Carpenter is an authority on cement and cement construction.

W. Wallace Boyd has been appointed assistant inspector of weights and measures at the Bureau of Standards, Washington, D. C. He was until recently in the employ of the Buffalo Scale Company, Buffalo, N. Y., in the capacity of scale engineer.

John Hunter, Manager, Am.Soc.M.E., represented the Society at the Annual Christmas Entertainment of the St. Louis Railway Club, Friday, December 10, at Trimp's Academy, St. Louis, Mo.

John W. Sheperdson has resigned his position of assistant general superintendent of the Central Iron and Steel Company, Harrisburg, Pa., and has accepted one with the Morgan Construction Company of Worcester, Mass. Mr. Sheperdson will take up his new duties in the early part of January.

Frank L. Glynn has accepted the invitation of the State Board of Industrial Education of Wisconsin to become general superintendent of the trade schools of that state. Mr. Glynn established the Boardman Trade School in New Haven in 1913, and under his management has become unique in trade school history. Previous to this he had organized the Albany Trade School and had had charge of the Bridgeport Trade School.

Thomas F. Fournier has accepted the position of general manager of The Standard Machinery Company of Mystic, Conn. He was formerly associated with the Becker Milling Machine Company, Hyde Park, Mass., in the capacity of chief engineer.

Richard E. Miller, recently associated with The J. W. Frazier Company as mechanical and electrical engineer, has become a member of the firm of Poland-Miller Company, Cleveland, O., which has been organized to conduct a general engineering business and will specialize in the design and inspection of coal, coke and ore handling machinery, docks and industrial plants.

Harry R. Westcott has opened an office in the Chamber of Commerce Building, New Haven, Conn., for general engineering practice and is prepared to investigate, design and supervise the erection and operation of power stations, mills, electrical installations, etc. Mr. Westcott was recently superintendent of construction for the United Illuminating Company of New Haven.

A. E. Berggren has accepted the position of mechanical engineer with the Faultless Rubber Company, Ashland, O. He was formerly instructor of steam and gas engineering at the University of Wisconsin, Madison, Wis.

Oliver M. Davis has become affiliated with the Oil Mill of Swift and Company at Augusta, Ga., in the capacity of constructing mechanical engineer. Mr. Davis was recently connected with The Shelby Company Cotton Oil Mill at Memphis, Tenn.

H. C. Beckwith, until recently Chicago manager of T. L. Smith Company of Milwaukee, has located at Ravenna, O., as treasurer and general manager of the Byers Machine Company, manufacturers of hoisting and excavating machinery.

Frederick W. Ballard of Cleveland, O., has been engaged by the city of Terre Haute, Ind., to act as the municipality's representative in lighting contract negotiations pending. Mr. Ballard is commissioner and chief engineer of the division of light and heat of the city of Cleveland.

At the December 17 meeting of the Worcester Polytechnic Institute branch of the American Institute of Electrical Engineers, Edwin B. Katte, chief engineer in charge of design, construction and operation of the New York Central lines, delivered an illustrated lecture on The Electrification of the Grand Central Terminal.

Thomas W. Ransom, consulting mechanical engineer in the office of the city engineer of San Francisco for a number of years, has tendered his resignation. Mr. Ransom retires to take up private practice and has opened engineering offices in the Merchants Exchange Building, San Francisco.

Charles S. Gooding has removed his offices from 28 School street to 27 School street, Boston, Mass., where he will continue his practice as solicitor of patents, mechanical engineer and expert in patent causes.

Frank E. Law, vice-president of the Fidelity and Casualty Company of New York, who is known not only as an underwriter of wide experience but also as a student of the subject of workmen's compensation, in answer to a communication from Miss Irene Sylvester, representing the American Association of Labor Legislation, gave his views and suggestions on the various amendments which it is proposed to ask the New Jersey Legislature to make in the New Jersey Workmen's Compensation Law. Mr. Law's letter to Miss Sylvester is published substantially in full in the issue of The Economic World for December 4, 1915.

Bertram W. Burtsell has accepted the position of sales manager of the Whitney Manufacturing Company of Hartford, Conn. He was formerly affiliated with the Packard Motor Car Company of Detroit, Mich., in the capacity of assistant factory manager.

Bertram G. Welchans has become associated with Stanley G. Flagg & Company, Pottstown, Pa., as mechanical engineer, in charge of manufacturing and machine design. He was recently connected with the Canadian Westinghouse Company, Ltd., Hamilton, Ont., Canada, in charge of the rate department.

Charles T. Main, Manager, Am.Soc.M.E., has been appointed chairman of a committee of this Society to coöperate with the Bureau of Standards in the matter of making suggestions for the tests of all sized columns in the Underwriters' Laboratories at Chicago.

Charles A. Stone, one of the two original members of the firm of Stone and Webster of Boston, Mass., and one of the most widely known men in the public-utility field, has been appointed president of the American International Corporation, recently formed to exploit the foreign trade of this country.

Charles P. Steinmetz delivered a lecture on Illuminating Engineering at the joint meeting of the Philadelphia section of the Illuminating Engineering Society and the Engineers' Club of Philadelphia, held on December 17.

F. H. Newell, professor of civil engineering at the University of Illinois, was one of the speakers at the first convention of the American Association of Engineers, Chicago, December 10 and 11. He outlined the problems of the engineer from the welfare standpoint.

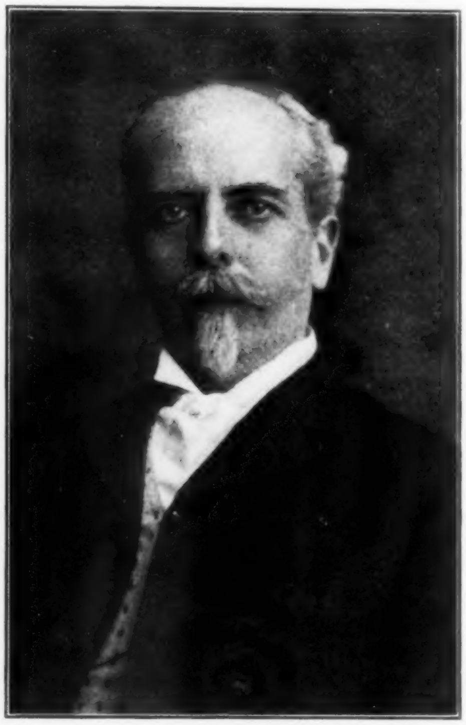
NECROLOGY

JAMES MAPES DODGE

James Mapes Dodge, Past-President of the Society, died at his home in Philadelphia, December 4, as a result of an attack of pneumonia contracted while returning from a visit to the Panama-Pacific International Exposition.

He was born at Waverly, N. J., June 30, 1850. His father was a member of the New York bar and his mother, Mary Mapes Dodge, was for many years the editor of the St. Nicholas Magazine, and the author of many delightful stories and poems for children.

Mr. Dodge was educated at Cornell University and at Rutgers, and had mechanical training in the shops of the Morgan Iron Works, New York City, and those of John Roach, the shipbuilder, at Chester, Pa., where he advanced to positions of foreman and superintendent of erection.



James Mapes Dodge

Shortly after the Centennial at Philadelphia, in 1876, he left the shipyard and later went to Chicago and joined with William D. Ewart, the inventor of the Ewart link belting, and his associates in the development of the chain business. At that time, about 35 years ago, the application of chains to power transmission was exceedingly limited and their use in elevating and conveying machinery was practically unknown. Mr. Dodge was alive to the opportunity and new types of chain, new methods of manufacture and new conveying and elevating appliances were brought out in rapid succession.

After this period of development Mr. Dodge entered into partnership at Philadelphia with Edward H. Burr, to represent the Ewart Manufacturing Company of Indianapolis, and out of this partnership grew in 1888 the Link-Belt Engineering Company in which Mr. Dodge carried out his idea of development along strictly engineering lines, with a highly-specialized engineering staff. Among other developments was the Dodge system of storage for anthracite coal, by which

the coal is stored in large conical piles and handled entirely by machinery, both in and out of storage. The Dodge Coal Storage Company was formed, and in 1892 Mr. Dodge was made president of this company, and of the Link-Belt Engineering Company. In 1906, when these and allied companies were merged and known as the Link-Belt Company, he was elected Chairman of the Board of Directors.

For many years Mr. Dodge was a close friend of the late Frederick W. Taylor and was the first to adopt in its entirety, at the Philadelphia plant of the Link-Belt Company, the Taylor system of Scientific Management. He made many contributions to the literature of scientific management and in these as well as in his spoken words and in the practical application of the system in his own plants, he held to the necessity for the mutual advancement of employee and employer. He showed always the greater concern for the welfare, happiness and success of the employee. His relations with his employees were both cordial and intimate, and his influence was to inspire self help, initiative and ambition, as well as to aid them when needed in every possible way.

Mr. Dodge was deeply interested in civic affairs and was president of the Public Service Committee of One Hundred and a member of the Committee of Seventy in Philadelphia, and in other ways was closely identified with the best interests of the city.

He became a member of The American Society of Mechanical Engineers in 1884 and served the Society in many ways thereafter. He was Manager from 1891 to 1894; Vice-President, 1900 to 1902, and President in 1903. He has been Chairman of the Public Relations Committee and of the Sub-Committee on Administration and in 1908 was Chairman of the Nominating Committee. His interest and belief in young men were shown by his presidential address before the Society on Money Value of Technical Training. At the meeting in Germany, one of the two papers presented by this Society was by Mr. Dodge on Industrial Management. Two other papers by him contributed to other meetings were: The History of the Introduction of a System of Shop Management, and New Method of Stocking and Reloading Coal.

The following brief appreciation by Prof. F. R. Hutton comes as a result of his intimate knowledge of Mr. Dodge, particularly in his relations with the Society:

Mr. Dodge had personal qualities of unusual charm. Many members of the Society first learned of his capacity for clever nonsense at the Atlantic City meeting of the Society in 1886, where he kept his audience in smiles with jest and story. Again in 1910, on the steamer trip across the Atlantic Ocean, his number on the program of entertainments was a delight. At solemn meetings of the Council of the Society, a quip or a jest from Mr. Dodge would relieve tension and clear the air. This made him much in demand for after dinner speaking.

It is to Mr. Dodge also, that the Society owes the original concept of placing the member's name on the lapel of the coat during the meetings of the Society. He was President of the Society for the year when the Carnegie gift to Engineering was made in 1904 of a building to house the national societies in New York. He was one of the first conference appointees, and later served on the building committee and on the Board of Trustees of the United Engineering Society. When the plans for the building were being worked over, Mr. Dodge had a wooden model made of the two lower floors from the architects' plans, and those who had decisions to make were greatly helped by the study of proportions which this model made possible.

Mr. Dodge had great capacity for friendship. No man was more appreciative of good work by others and he was generous in his expressed commendation. He will be missed sorely by many who came near to him.

GUSTAVUS TYLER LUCKETT

Gustavus Tyler Luckett was born at Owensboro, Kentucky, on February 26, 1870. He received his early education in the schools of Owensboro and then went to Trinity College near Louisville, Ky. From 1888 to 1896, he held a position as machinist and pattern maker, and molder superintendent, with the Novelty Foundry and Machine Company at Owensboro, Ky. From 1898 to 1900 he was assistant superintendent in charge of construction for the N. Y. Edison Company. He left them to go with the Best Manufacturing Company as their New York representative. From 1901 to the time of his death, he was with the M. W. Kellogg Company. He had active charge of designing steam and hydraulic piping, machines for the manufacture of Van Stone joints and improvements thereon, welding flanges, forge welding shells, piping, piping outlets and construction and erection of piping systems. Mr. Kellogg died at his home in New York City on July 16, 1915.

THOMAS L. RANKIN

Thomas L. Rankin was born at Ripley, Ohio, on June 16, 1839. He received his education at Iberia College at Iberia, Ohio, from which he graduated in 1855. In 1869, he began to build isolated refrigerating cars in the West at Barney and Smith, Dayton, Ohio. In 1873, he built 50 of the refrigerator cars at Wasson Works in Springfield, Mass. Previous to this date, he had laid many iron floors for refrigerating breweries and packing houses. From 1873 to 1877, he was superintendent of the Arctic Ice Machine Company, with many plants in Texas, Arkansas and Louisiana. During this time and through 1891 he continued the construction of ice machines at Phoenix Works, Houston, Texas, at the Atlas Works, Indianapolis and Reading Iron Works, Reading, Pa. He later had charge of the ice machine department of the Pennsylvania Iron Works Company of Philadelphia, Pa.

Mr. Rankin became a member of the Society in 1892. He died at his home in Sacketts Harbor, N. Y., on November 12, 1915.

BAXTER D. WHITNEY

Baxter D. Whitney was born in Winchendon, Mass., in 1817. His early education was received in Winchendon, Hancock, N. H., and Fitchburg, Mass., but his business life started in his father's woolen mill when he was very young. When he was ten years old, he constructed a saw mill, run by water, which, while merely a boy's effort, was prophetic of the line which his activities later followed. When he was 13 years old, he went to Worcester to help build some looms for his father.

At 16 years of age, he constructed an 18 in. by 6 ft. engine lathe, designing and making the patterns and machining the castings. It had a large wormwheel feed and a V-bed which he milled with a special fixture comprising wooden beams laid in the floor.

In 1836, he began the construction of machinery for making tubs and pails and had 28 men working for him. The next year, he built sixteen looms for cashmere and later he built two or three steam jigs. In 1845, he built for himself a foundry and machine shop and the next year the first Whitney wood-planing machine, which took six weeks to construct, was built. This is still in existence and is claimed to be the first cylinder planer ever made which was a practical success.

In 1857, he built a scraping machine and also a shaper and the famous Whitney gage lathe. During the Civil War, he was busy making gun-stock machinery.

Mr. Whitney received medals for his machines at exhibitions in Paris (1867), Vienna (1873) and Philadelphia, (1876).

Mr. Whitney became a member of the Society in 1886. He died at his home in Winchendon on October 17, 1915.

STEPHEN BETTS WHITING

Stephen Betts Whiting was born at Reading-Ridge, Connecticut, on January 22, 1834. After attending the public schools of his native town and of New Haven, Conn., Mr. Whiting finished his schooling with a year at the New Haven Collegiate & Commercial Institute.

When fifteen years of age, he was apprenticed to the machinist trade and, before he was sixteen, he designed and constructed a miniature steam engine. When seventeen years of age, he designed and built an air-pump. At this time, also, he went to work as a full-fledged journeyman.

In 1855, when Mr. Whiting was only twenty-one years of age, he was sent to Urbana, Ohio, to take charge of the shops of the Urbana Machine Company, and in 1857 he went to Alton, Ill., as superintendent of the Illinois Iron Works.

In 1860, he returned East and took charge of the Kaighn's Point Iron Works at Camden, N. J. At this time he came in contact again with his old friend and schoolmate, Charles G. Wilcox; the two men formed a partnership, bought the Kaighn's Point Iron Works and operated it under the firm name of Wilcox & Whiting.

This firm built and erected the superstructure of the Chestnut Street Bridge over the Schuylkill River in Philadelphia. The date of the contract covering this work was July 18, 1861, and the contract price was $134,577.00. The firm also built the U. S. Monitor Koka, which was one of the light-draft monitors designed by John Ericsson. The date of this contract was May 18, 1863, and the contract price was $386,-000.00. Some of the principal dimensions of this vessel were as follows: Overall length, 225 ft.; beam, 45 ft.; draft, 6½ ft.; diameter of turret, 20 ft.; height of turret, 9 ft. The motive power consisted of two 22 by 30 in. single-cylinder engines direct connected to two propeller shafts, each of which was fitted with a 9 ft. propeller. The armament consisted of one 11 in. gun and one 150 lb. rifle.

Early in 1865 the Kaighn's Point Iron Works were sold and on July 1, 1865, Mr. Whiting went to Pottsville, Pa., as superintendent of the Colliery Iron Works.

In this position his inventive faculty often came into useful play in connection with the design and manufacture of machinery for the coal regions. He designed the so-called Whiting system of rope driving, hauling and hoisting machinery which was first installed at the Lehigh & Wilkesbarre planes at Solomon's Gap, Wilkesbarre, Pa. At later dates this system was adopted for the Mahoney planes of the Philadelphia & Reading Coal & Iron Company, for the Brooklyn Bridge, for the Red Jacket or Whiting shaft of the Calumet & Hecla Mining Company, and for a number of the diamond mines of South Africa.

On September 1, 1878, Mr. Whiting entered the employ of the Philadelphia & Reading Coal & Iron Company as mechanical engineer. On April 1, 1880, he was promoted to chief engineer, and on March 1, 1883, to general manager, which latter position he held for five years.

On May 1, 1888, Mr. Whiting entered the employ of the Calumet & Hecla Mining Company as general manager, which position he held until April 30, 1901, when he retired from active life.

While with this company he recommended and supervised the sinking of the Red Jacket or Whiting shaft. This is a vertical, six-compartment shaft which intersects the lode at a depth of about 3300 ft. and reaches the level of the lode at the property line at a depth of 5000 ft. The cross-section of the shaft measures 15½ by 25 ft.

Mr. Whiting was a charter member of The American Society of Mechanical Engineers, manager from April 1880 to November 1882 and vice-president from 1882 to 1883. He was also a member of the American Society of Naval Engineers, the American Institute of Mining Engineers, the English Institution of Mechanical Engineers and the North of England Institute of Mining & Mechanical Engineers.

Mr. Whiting died at his residence in Cambridge, Mass., on December 23, 1915.

MEETINGS

CINCINNATI, NOVEMBER 18

The regular November meeting of the Cincinnati Section of the Society was held as a joint meeting with the Engineers' Club of Cincinnati on November 18. C. R. Underhill, chief electrical engineer of the Acme Wire Company, New Haven, Conn., spoke on Electromagnets. Mr. Underhill in his talk first reviewed briefly some of the steps in the historical development in the study of solenoids. The fundamental principle and properties of solenoids were demonstrated experimentally by means of suitable apparatus and attention was called to changes in their behavior when supplied with alternating instead of direct current. The reasons for the less satisfactory operation of the A.C. solenoid as regards its holding power and noisiness were discussed and the remedies employed and being studied, were outlined. Attention was called to the early theoretical analysis of solenoids by Clerk Maxwell and by a reference to his fundamental force equation

$$F = 2\pi T^2 + TH + \frac{H^2}{8\pi}$$

it was shown that in the study of solenoids and magnets, the design is greatly facilitated by regarding the three components of the total force independently, that is, the force reaction between the solenoids or parts of solenoids, the force between solenoids and plungers, and the force manifested at air gaps. Emphasis was placed upon the fact that many of the methods of procedure in the design of magnets and solenoids are cumbersome because of the attempt to consider the force developed as the function of a single composite field; some methods are inadequate because they fail to recognize that it is the magnetic leakage that calls for the greatest consideration.

Lantern slides were shown exhibiting the correspondence between theoretical and observed performances of solenoids. Views were also presented showing some common commercial applications of magnets and solenoids such as, lifting magnets, magnetic clutches, magnetic chucks or separators, magnetic brakes, electromagnetic impact tools, etc. At the conclusion of the paper a discussion occurred which was followed by the usual Dutch lunch. About 100 members and guests were present.

CHICAGO, NOVEMBER 19

The first meeting of the Chicago Section of The American Society of Mechanical Engineers for the 1915-16 season was held on November 19, with H. M. Montgomery, *Chairman*, presiding. Dinner was served promptly at 6:30 p.m. to 122 members and guests.

The speakers were Frank B. Gilbreth, Mem.Am.Soc.M.E., consulting engineer, Providence, R. I., and Hon. Jacob M. Dickinson, receiver, Chicago, Rock Island & Pacific Ry.

Mr. Gilbreth gave an illustrated lecture on the subject of Helping Crippled Soldiers. He explained that he had been requested by representatives of foreign educational departments to train teachers in the theory and practice of motion study in order that they may be able to develop methods and means by which it will be possible for the maimed and injured soldiers at the close of the war to become productive units in the industrial development of their respective countries. By doing this, the cripples can be made self-supporting, which will relieve their country of a considerable burden and at the same time provide occupation for the men with the accompanying increase in happiness. The experience gained by the study of motion study is expected to assist in the determination of occupations for the injured soldiers, provided they are incapable of following their previous trades, and the arrangement of the tools with which they work so that they can perform their work in an efficient manner and with minimum fatigue. He explained in some considerable detail, the methods followed in making motion studies and showed by means of lantern slides many interesting problems, such as machine tool work, brick laying, etc., in which the fatigue of the worker had been materially lessened by the placing of the materials used in his work in more convenient positions. The method followed in such cases was to take photographs of the paths followed by the worker's hand in making one complete cycle of operations. This was accomplished by fastening a small electric light to the workman's hand, the path of this light being clearly shown in the photograph. The electric current to the lamp was interrupted at regular intervals measured to the thousandth of a second, the interruptions being controlled by tuning forks of a predetermined number of vibrations per second. This produced in the picture an intermittent series of light and dark spots in the path of the lamp which gave an indication of the speed of the workman's hand throughout the cycle of the operation. From these photographs, wire diagrams were made for the purpose of more carefully studying the complete cycle of the motion with the idea in view of simplifying them with the accompanying reduction in fatigue to the workman and increase in output.

Mr. Gilbreth laid great stress on the importance of providing every means possible for the occupation of the injured soldier after the war, from the standpoint of the soldier himself, his country and the world at large. He solicited information from all who had any suggestions to offer regarding this line of work, and from those especially who knew of any devices used by men who were physically handicapped in performing their work in the ordinary way.

Mr. Dickinson, the second speaker of the evening, expressed much interest in the lecture given by Mr. Gilbreth, and spoke of the urgent need of such work in the warring countries. Having been in the Civil War he appreciated greatly what opportunities were ahead of Mr. Gilbreth. He spoke of former Governor Nichols of the state of Louisiana who emerged from the Confederate army with one leg and one eye, as illustrative of two points that should be considered; namely, that a man need not despair on account of misfortunes incurred in the war and the effect of the pension system. General Nichols served in the Confederate army and his country was unable to give him a pension at the end of the war, so he went back to his profession, the practice of law, and notwithstanding his injuries, was eminently successful, becoming governor of Louisiana. Had he received a pension he would have been able to retire and the country might have lost the civil service of an able man. While Mr. Dickinson did not want to be understood as opposing a pension to those who become dependent on account of service to their country, he believed that from the study he has given to the question that a great deal of harm comes from indiscriminate pensions. He told how, after the Civil War, the pension system was dominated by the claim agents who lived on the percentages of the pensions obtained for those who were not very discriminating regarding the matter of disability. In this way a vast amount of money was bestowed on people whose injuries were far from making them non-supporting.

This indiscriminate pensioning was quite extensive in eastern Tennessee and its effect on the following generation was clearly shown at the close of the Spanish War. Four regiments from that state were raised for the Spanish War; one from the eastern part, one from the middle, one from the western part, and one called the "regiment of immunes," the idea being that those immuned from yellow fever would be liable to be called for service more rapidly. After the war was over and all these soldiers were mustered out of service they were asked whether or not they claimed anything for disability on account of serving the government and a record was made of these claims. Those soldiers from east Tennessee who were individually just as good men as the soldiers of west Tennessee, but who had been imbued with this idea of the pension system and of the duties and obligations of the government arriving simply from the fact of having rendered service, presented claims for 60 per cent of their number, whereas the regiments from the middle and west Tennessee put in claims for less than 10 per cent of their number.

In closing, Mr. Dickinson called Mr. Gilbreth's attention to the big field for his motion study work in the process of picking cotton in the South, stating that up to this time there has not been invented a satisfactory cotton picking machine and all that work has to be done by hand.

WORCESTER, NOVEMBER 23

At a meeting of the Worcester Section of the Society on November 23, Frank B. Gilbreth presented his paper on Motion Study for Crippled Soldiers in substantially the same form as it appeared in the December issue of The Journal.

BOSTON, NOVEMBER 30

At a meeting of the Boston local section of the Society on November 30, a paper was presented by Frank B. Gilbreth, Mem.Am.Soc.M.E., on Motion Study for Crippled Soldiers. Mr. Gilbreth stated that there are today over two million men living in Europe who have suffered the loss of limbs, faculties, or both, as a result of injuries in the great war. He said that provisions must be made for enabling these millions of crippled soldiers to become self-supporting, that they must be taught and fitted for some sort of productive work and the work must be specially modified and adapted to their individual physical defects and shortcomings, that the problem is an exaggerated new form of vocational guidance, vocational training and systematic placement of men. Mr. Gilbreth visited many hospitals and recovery homes and has seen first hand the frightful needs. Having crossed more than a dozen European frontiers since the war began, Mr. Gilbreth stated that he felt justified in emphasizing the necessity of this great movement of systematic teaching of crippled

soldiers. Mr. Gilbreth described a number of slides showing motion study of various kinds. By the analysis of the various motions it is possible to work out new sequences, cycles, and methods of doing many a type of work that has been formerly considered possible only for the man who is in complete possession of all his members and faculties. It is possible to take a maimed soldier or other worker to be helped, specially equip or fit him for a new set or new sequence of motions which will enable him to achieve an output of production not only large enough to allow him to be considered an active and productive member of society but also, with some types of work, to hold his attention and interest sufficiently to enable him to progress continually in his learning and skill.

ST. LOUIS, NOVEMBER 24

On November 24, a joint meeting of the Associated Societies of St. Louis was held under the auspices of the American Society of Civil Engineers. H. R. Stanford, U.S.N., Chief of the Bureau of Yards and Docks, gave an illustrated lecture on the Pearl Harbor Dry Dock. He discussed the dock from start to finish, particularly dwelling on the difficulties encountered through the bursting upward of the bottom of the dock through hydraulic pressure. The attendance was about 125.

ST. LOUIS, DECEMBER 1

On December 1, a joint meeting was held under the auspices of the American Society of Engineering Contractors. Hillis F. Hackedorn, president of the Hackedorn Contracting Company of Indianapolis, and also president of the American Society of Engineering Contractors, gave a paper on Equitable Specifications and Contracts. The paper was presented from the contractor's point of view. Mr. Hackedorn's contention was that the average engineer or inspector possesses no more of the qualities of angels than does the average contractor, and that a specification which places the final decision on all matters in the hands of a possible faulty inspector is not a just paper before the law. Such a contract further lacks many of the elements of common sense in its makeup. Mr. Hackedorn pleaded for a uniform building contract which would be fair to all parties concerned and advised that such a form was pretty well developed and it is to be before long that no contractor will undertake work unless this contract form is used.

BUFFALO, DECEMBER 1

At a meeting of the Engineering Society of Buffalo on December 1 Fay B. Williams, Mem.Am.Soc.M.E., engineer of the Lamson Conveyor Company, of Boston, Mass., gave a lecture on Internal Conveyors. The lecture was very profusely illustrated with slides and the various types of conveyors consisting of tubes, overhead wires, runways, etc., were thoroughly gone into. Mr. Williams described various systems of conveyors for carrying packages, parcels, goods, mail, etc., inside buildings. According to him, modern efficiency methods demand just as efficient means of internal transportation as of road transportation. About 175 members were present.

BUFFALO, DECEMBER 15

At a meeting of the Engineering Society of Buffalo on December 15, C. E. Drayer, Secretary of the Cleveland Engineering Society gave an address on Engineers in Politics. On January 1, the city of Buffalo enters on a new form of government, a commission form of government with four councilmen and one mayor as the governing body of the city. Mr. Drayer said that the building of railroads, canals, water-supply and sewerage systems, are fundamentally public service but do not relieve the engineer of his other duties as a citizen. On the other hand, the public character of his work creates new opportunities for civic leadership and increases his responsibility as a citizen. Mr. Drayer argued that the usual engineer was lax in his duties as a citizen, that he had special knowledge and training which might be turned to the common welfare of the community. He said that the local society of engineers could at least furnish through its committees and open meetings, a forum where analytical minds can help solve the problems about which engineers are qualified to speak. Mr. Drayer told what had been accomplished in Cleveland by the engineers of the city, how they are called on by the mayor and council in settling engineering questions. He showed many slides and newspaper clippings to show what interest was aroused by the Engineering Society in Cleveland and the great variety of topics that might be suggested for public discussion. This meeting was attended by approximately 175 and the tone of the meeting was one of heartiest coöperation in all forms of civic life.

PROVIDENCE, DECEMBER 15

The last meeting of the Providence Association of Mechanical Engineers for the year 1915, was held at Brown University on December 15. Prof. Charles W. Brown, head of the Department of Geology, addressed the meeting on Geology and Engineering. His talk was very well illustrated by the use of an epediascope, by means of which photographs and microscopic projections were thrown on the screen. At the close of the lecture the members had an opportunity to inspect the museum of the University with particular reference to the geological specimens.

CINCINNATI, DECEMBER 16

A joint meeting of the Engineers' Club of Cincinnati and the Cincinnati Section of the Society was held on December 16. Instead of the usual formal address, the retiring president of the Engineers' Club, F. L. Raschig, chose as his subject Engineering Features of the Panama Pacific International Exposition, following a paper which was presented at the San Francisco Meeting of the Society in September by Guy L. Bailey, Mem.Am.Soc.M.E. Through the courtesy of Mr. Bailey, about 90 lantern slides illustrating many of the engineering features of the Exposition were shown.

MINNESOTA, DECEMBER 16

The regular meeting of the Minnesota Section was held in St. Paul on December 16. Prof. J. J. Flather, Mem.Am.Soc.M.E., gave a paper on Engineering Education in the British Isles, and Mr. Brink presented one on Government Specifications with special description of a 50 ton crane which the American Hoist and Derrick Company is building for the Government.

Quincy A. Hall, in the absence of the Chairman, Mr. Toltz, made the following report of the Nominating Committee: C. W. Tubby, *chairman;* J. B. Martenis, *vice-chairman;* F. W. Rose, *secretary and treasurer.* F. W. Rose resigned and placed in nomination Quincy A. Hall, who was elected.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The December Meeting of the Armour Institute of Technology Student Branch was held on December 2. B. S. Carr, who is a senior mechanical and employed by the Grip Nut Company of Chicago, gave a talk and demonstration on grip nuts. He explained the entire process of their making and by means of a Riehle Testing Machine demonstrated the locking power of the grip nuts. Following Mr. Carr's talk, an open discussion was held on the subject of The Testing of Glued Wood Surfaces for Tension.

CARNEGIE INSTITUTE OF TECHNOLOGY

A meeting of the Carnegie Institute of Technology Student Branch was held on November 10, at which Prof. G. H. Follows, head of the department of machine design, addressed the Branch on Some Things that Experience Has Taught Me up to Date. He opened his talk with a summary of the positions that he had held in his past twenty-four years of engineering experience, which included almost everything that a mechanical engineer could do and still retain his calling.

Professor Follows said that the greatest lesson he ever learned was that interest in the work is the key note of success. Following this, he spoke at some length on requirements for a design to be good and also spoke of the poor returns from working with patents. He closed his talk with a very fine discussion of efficiency in general and personal efficiency. Following the address an informal discussion was held by Professor Follows and those present.

At a meeting of the Branch on December 8, H. H. Hower, of The Willys Overland Company in Toledo, gave an illustrated lecture on the subject of The Sleeve Valve Motor of the Silent Knight type. Mr. Hower presented each man with a paste board working model of the sleeve valve motor, and made use of these, in addition to a number of slides, to illustrate the points of his talk. The following is a brief summary of the considerations taken up:

The sleeve valve motor differs from the poppet valve motor only in the method of making passage for the inlet and exhaust gases. The other essential parts correspond very closely with those of the usual poppet valve motor. These passages are made by two concentric sleeves around the piston reciprocated by eccentrics on a counter shaft so that at the proper time the ports in the sleeves register with each other and with the ports in the cylinder walls proper allowing a large clear passage for the gases. The cylinder head fits down in the inner sleeve and has a junk ring to hold the compression. The sleeves are so arranged and operated that no port is exposed to the fire of the explosion, and the inner sleeve operates in the direction of the piston on the compression and power strokes.

In comparing it with the poppet valve, the following points were brought out in favor of the sleeve valve: Positive, quiet action; spherical combustion chamber; large clear passages; no grinding; and better possible wearing qualities.

Contrary to the general idea, the lubrication of the sleeves and piston assembly is more than adequate. A simple splash system is used, and in tests, bearings have been burnt out for want of oil while the sleeves were running well under the same supply as the bearings. The grooves in the sleeves have to be cut to prevent too much oil from working up the sides of the sleeves.

A discussion followed the talk. The question of whether cam and spring operated valves were positive in action at high speeds was taken up at some length. It was brought out that aluminum could not be used for pistons or valves in this kind of a motor because excessive heat expansion would prevent its being used where there were a number of close running fits. The cost of manufacture was found to be much in excess of that of the poppet valve motor.

COLORADO AGRICULTURAL COLLEGE

The Student Branch of the Colorado Agricultural College held a meeting on October 11, at which Oliver P. Hall, Mem.Am.Soc.M.E., gave a talk on the testing of automobile motors. His discussion was mainly in regard to the Standard Test. In discussing the apparatus used, he said that of prime importance is some sort of a brake to measure the horse power of the motor, in some cases a prony brake is used, while in others the electrical dynamometer is used. The latter instrument is the newest piece of apparatus used at the present time for the testing of motors. Mr. Hall gave a detailed description of the dynamometer, illustrating with blackboard drawings, and told of the methods of carrying on the test.

At a meeting of the Branch on October 25, Mr. England gave a talk on Compressed Air Mining Machinery. In his discussion he took up the old style steam, electric and gas engine compressors, and also the new electric compressors. In his talk, he touched upon the subject of drills and drill machines used at the present time. His talk was based on actual experience as gained in the metal mines of the Cripple Creek district.

Another meeting of the Branch was held on November 22. T. H. Sackett gave a talk on the ore-dressing machinery and processes of ore-dressing as used in the metal mines of the Telluride district of Colorado. He described by use of diagrams on the board the following pieces of apparatus used: Ore crushers, bins, stamps, amalgam plates, amalgamator classifiers, Wolfley tables and other apparatus used in the amalgam and cyanide processes of gold extraction. His discussion was well received and very interesting.

A fourth meeting of the branch was held on December 13, at which Prof. L. D. Crane gave a talk on National Preparedness. Prof. Crane made his remarks on the subject of civilian or voluntary service such as is now in vogue in the Navy Department of our Government under Secretary of the Navy, Josephus Daniels.

COLUMBIA UNIVERSITY

At a joint meeting of the electrical and mechanical engineering societies of Columbia University on November 23, Captain Robinson, C. E., of the 22nd Regiment, N. Y., spoke of The Work of the Military Engineer. The speaker was introduced by Dean F. A. Goetze, Mem.Am.Soc.M.E., and of the Faculty of the School of Applied Science. Captain Robinson pointed out strongly the great difference between civilian and military engineering. This difference is so great that, though a man is an engineer in everyday life, he is not fitted for military work without special training. This work includes all the regular infantry training in addition to the duties as an engineer. As Captain Robinson spoke of the different features of his subject, he illustrated the lecture with slides, motion pictures and models. The models of the different types of military bridges, small sized pontoons, etc., were remarkable. The military engineer has to be destructive as well as constructive, and, to illustrate this, two reels of moving pictures were run off showing explosions of earth mines and those under water with the resultant effects. Included in this were pictures showing the demolition of bridges and railroads.

KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College Student Branch on December 2, Lieut. Mathews, Commandant of Cadets at the College, gave a talk on Engineering as Applied to Field Fortification. He brought out the comparison between the ancient and modern methods of fortification. He spoke of the part that the engineer is expected to do in regard to field fortification, and also described the kinds of field obstruction and fortifications which are being used in Europe at the present time.

Prof. R. A. Seaton of the Applied Mechanics Department gave a description of A Trip to the Pacific Coast in an Auto. He described especially the kinds of roads and bridges in the west and in the mountains.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Student Branch of the Massachusetts Institute of Technology opened the year on October 9 with a trip through the new Institute buildings now under construction in Cambridge, at which one hundred and sixty-two men were present. The party was split up into small groups and shown about the buildings by instructors in the Mechanical Engineering department. Although no machinery has as yet been installed, the men were able to see the magnitude of the work and the general arrangement of the different departments. The me-

chanical laboratories were equipped with two canals in the basement which will furnish all the water used in the hydraulic work and also for the condensers. On the first floor will be placed the testing units, most of which will be entirely new. The power house, which is connected with the main building by a tunnel, is rapidly nearing completion. 2000 h.p. of Babcock and Wilcox boilers will be installed in 300 h.p. units.

The first smoker of the year was held in the Technology Union, the speakers being Professors Miller and Hayward of the Institute and A. B. Carhart, Mem.Soc.M.E., of the Crosby Steam Gage Company. Professor Miller spoke of the advantages of membership in the Am.Soc.M.E., while Professor Hayward gave some interesting advice to the men in regard to promptness and zeal in the work they undertake. Mr. Carhart outlined the progress in the past along engineering lines, and also mentioned some ways along which advancement may be expected in the future.

On October 30, a trip was made to the Chestnut Hill Pumping Station of the Boston Water Works with an attendance of sixty. On reaching the station each man was given a paper on which the most interesting points were noted. This particular station was of much value to the men, as there is such a variety of equipment. The boiler room has seven vertical fire tube boilers, one of the locomotive type, and three horizontal boilers running with stokers and forced draft. The pumping engines are of 35, 45, 20 and, two of 8 million gallons a day capacity. There is also an Allis engine that for a number of years held the world's economy record.

On November 11, W. S. Perkins of the Walker Pratt Foundry gave an illustrated talk, which followed the progress of the metal from the mine to the finished product.

On November 27, there was a trip to the L Street Station of the Boston Edison Company, where eight vertical turbo-generators of 96,000 kw total rated capacity were seen in operation. The coal handling system from vessel to boiler was one of the interesting features that was noted. Here as in the former trip neostyled sheets were given out showing where to see the interesting points; these also contained considerable data and a general description of the plant. From the Edison plant, the men went to that of the Boston Elevated system, where three 15,000 kw units were seen in operation. A description of the condensers, main units, feed water heaters, boilers, etc., was given the men, and, in company with several professors and officers of the society, who went over the plant a few days previous, the piping system was traced out and different features of the equipment noted.

The officers for the ensuing year are: K. C. Richmond, '16, chairman; P. Y. Loo, '16, vice chairman; H. B. Gray, '16, secretary; J. W. Stafford, '16, treasurer; R. M. Snyder, '16; G. W. Tuttle, '16, and E. W. Rounds, '17, governing board.

PENNSYLVANIA STATE COLLEGE

At a meeting of the Pennsylvania State College on November 18, H. L. Mummert, '16, was appointed by the Advisory Committee as the representative of Pennsylvania State College to the Annual Meeting of the Society in New York.

Samuel Clark, '16, gave a lengthy discussion of the Willys-Overland automobile industry. He supplemented his talk with stereopticon views of the Toledo plant, showing views from nearly all of the departments, and more especially the motor assembly department. He described the methods used in assembling the motors, and also spoke of the accuracy demanded in making up the various parts. He illustrated with lantern slides the working parts of the motor, and especially the sleeve valve system, which he discussed in detail. The speaker helped to explain the sleeve valve by the use of a miniature working model of the motor in cross-section.

Mr. Clark also described the treatment of employees by the Willys-Overland concern, and explained several points in connection with the handling of the men.

At this meeting, G. S. West was chosen as vice-president to succeed Mr. Dunn.

POLYTECHNIC INSTITUTE OF BROOKLYN.

At a meeting of the Polytechnic Institute of Brooklyn Student Branch on November 6, George A. Orrok, Mem.Am. Soc.M.E. and chief mechanical engineer of the New York Edison Company, spoke on Tendencies of Central Power Station Design. He traced the development of central power stations from the first station built by Edison over thirty years ago to the model and standard stations of to-day both in Europe and in this country. He showed how boilers have been improved and how they can now produce a pressure of 350 lb. per sq. in., although the usual working pressure is 175 lb. Likewise the motive power for directly driven dynamos has passed through several stages, from compound engines to triple expansion, to quadruple expansion engines, back to compound engines, and finally to the highly efficient and economical turbine now in vogue.

In power plant design, there evolved two types of central power stations, the European and American Standard. The European design includes boiler room, turbine room, electric auxiliaries and economizers, while the American Standard involves boiler room, turbine room, steam auxiliaries and feed water heaters without economizers.

The greatest tendency in central power station design in this country is toward the extensive adoption of the economizer. This equipment, which raises the temperature of the water from the feed water heater before injecting it directly in the boiler is claimed to increase the efficiency 4 per cent.

The December meeting of the Branch was held December 10 at the rooms of the Society in New York. Fred R. Low, Mem. Am.Soc.M.E., and Editor of Power, gave an illustrated talk on the Panama Pacific Exposition. The Panama Exposition has been the only exposition with consistent layout of buildings, which can be explained by the fact that the site of the exposition was formerly under water. The speaker dwelt at length on the palace of machinery, which required 7½ million board feet of lumber and 15 tons of building hardware in its construction. Mr. Low impressed his listeners with the fact that the exposition contained very little to commemorate the Panama Canal or to impress the visitor with the immense strides which have been taken in engineering in the past decade. Colored slides portrayed the beautiful color scheme used in the decorations of the buildings.

PURDUE UNIVERSITY

A joint meeting of the Purdue University Student Branch of the Society and the A.I.E.E. was held November 22. W. A. Phillis, of the National Tube Company, gave a lecture on the manufacture of steel pipe and tubing. He illustrated his talk with three reels of motion pictures. The first reel showed the "open-cut mining" of the Great Lakes region being carried out on a mammoth scale. The advanced methods of loading and transportation were of special interest, and excellent pictures of the charging of the blast furnace were shown. The second reel portrayed the refining of the steel and the rolling and forming it into the finished product. The steel is refined in the Bessemer and open hearth furnaces, depending upon the style of pipe to be made and the quality of the iron. Probably the most interesting feature was the great amount of automatic machinery for handling the rolled stock. The steel is first rolled into sheets and then formed into the pipe, using a butt weld up to a certain size and then the lap weld in the larger sizes. The third reel concluded the manufacture of the pipe, and in addition showed the rigid tests to which the finished product is subjected. Every piece is tested for compression in both directions, the weld is tested, a water test and a personal inspection complete the test. A panoramic view of the immense factories at Lorain, Ohio, concluded the film. Few opportunities have been afforded the engineering societies for seeing such an unusual motion picture of a big industry as that shown to the engineering societies of Purdue by the National Tube Company.

Another meeting of the Branch was held December 7. The program consisted of talks given by three of the members. The first was a talk on ship-building, by Mr. Shoemaker. He is a native of Holland and has had considerable experience in repair work on large vessels. He gave a very instructive account of the method of re-boring worn steam cylinders by setting the mill right in the cylinder. An account of the exchange of propellers in mid-ocean was given. The cargo was shifted to the forward part of the ship until the propeller was out of water. A scaffold was then built around the propeller and it was removed. Mr. Shoemaker's statement that the bearing surface of the journal of the propeller was made of wood was received with a great deal of interest and curiosity.

The next talk was given by O. F. Hambrock, '16, on Replacing of Boiler Tubes. He gave the various methods of fastening the tube to the plate; by putting a bead on the inside by means of a special tool (pneumatic), and also a new theory proposed by a foreign experimenter, namely, increasing the thickness of the tube at its entrance to the plate by the addition of a softer metal. This, it is claimed, will remedy loosening of the tubes due to expansion in heating. Mr. Hambrock gave his ideas on the practicability of the scheme. He told of the probable difficulty in welding, and also of the decrease in size of the spaces between the tubes and the resultant increased opportunity for the lodgment of dirt. He also discussed the warping effect due to unequal heating of the pipes.

The third talk was a short discussion on Fallacies in Cement Testing. This was given by W. Rhoton '16. Lack of a more specific standardization of the constituents of cement and of the size of the mesh used in screening are the largest contributants to fallacious tests on cement. It was also brought out that tests run on the material immediately after manufacture are not a true indication of its quality after it has been stored away in bags for a time.

RENSSELAER POLYTECHNIC INSTITUTE

The third regular meeting of the Rensselaer Polytechnic Institute Student Branch was held on November 11. J. B. Lincoln, president of the Branch, gave a very interesting description of the "L" Street Station of the Edison Electric Illuminating Company in Boston, Mass. Among the interesting facts given by Mr. Lincoln were the following: The rated turbine capacity of this plant is 140,600 h.p.; the turbines are of the vertical Curtiss type and are eight in number; each turbine is installed as an independent unit and can be fed with steam from any one of 48 Babcock and Wilcox boilers. These boilers are placed in the boiler room parallel to and separated from the turbine room by only a brick wall, thus making short steam lines and consequently a small per cent condensation. Water is fed to the boilers from the city mains but a reserve auxiliary storage tank is kept filled as a reserve supply in case of shortage of city water. Since the plant is located on Boston Harbor, all coal is brought to the plant in ships and is stored in the open air in the rear of the Power House. This coal is carried to the boiler room by means of belt conveyors. Circulating water is pumped to the condensers from the harbor.

Prof. A. M. Greene, Jr., Mem.Soc.M.E., and head of the mechanical engineering department, then gave a very interesting discussion of the papers which appeared in the November issue of The Journal. Professor Greene confined his discussion chiefly to the papers on The Diesel Engine and its Application to Southern California by Walter H. Adams and The Heavy Oil Engine, its present Status and Future Development, by A. H. Goldingham. He laid special emphasis on Mr. Adams' comparison of the Otto and Diesel cycles and on the advantages and disadvantages of two cycle and four cycle engines.

STATE UNIVERSITY OF IOWA

The first regular meeting of the State University of Iowa Student Branch was held on December 1, at which Harry F. Helming was elected chairman to succeed C. W. Harrison; H. V. Swanson and Geo. Gartzke were elected members of the governing committee. At a meeting of the Branch on December 14, Mr. William Howe, member of the Branch, gave a short talk on the History of the Association and the advantages to be derived by the students in becoming affiliated with the Branch. He also emphasized the value of The Journal to the undergraduate.

SYRACUSE UNIVERSITY

At a meeting of the Syracuse University Student Branch on December 6, Hiram Percy Maxim gave a lecture on his invention, the Maxim Silencer. Mr. Maxim told in a very interesting way how the idea of his invention first came to him and of the interesting experiences he has had with trying it out. Mr. Maxim said that one morning as he was stepping out of the bathtub, he noticed a whirlpool with the air space in the center which kept the water from running out freely. Immediately the thought came to him that if he could make the gases coming from the barrel of a gun whirl in the same way they would be retarded and hence there would be no noise. Immediately Mr. Maxim set to work upon this idea and soon had a real silencer.

Mr. Maxim then explained why a gun having a silencer upon it is not absolutely quiet when fired. The noise which he cannot quiet is caused by the bullet passing through the air. This noise cannot be overcome without reducing the speed of the bullet.

Mr. Maxim also pointed out why a revolver is not silenced by his invention. The reason is that there is a space between the chamber and the barrel through which the gases escape. Mr. Maxim concluded his lecture by demonstration with different sized rifles and the revolver.

UNIVERSITY OF CALIFORNIA

At a meeting of the University of California Student Branch on November 23, H. Crow gave a paper on the Relation of Engine Balance to Automobile Vibration in which the author considered chiefly the four, six and eight cylinder engines.

C. Sebastian also gave a paper on the Electric Furnace and the Steel Industry in which the author considered the application of the electric furnace in the production of high grade steels.

UNIVERSITY OF CINCINNATI

On November 19, Mr. Walker of the Enger Motor Car Company addressed the University of Cincinnati Student Branch on the Twelve Cylinder Motor Car. He began by explaining the conditions leading to the adoption of the twin six by the Enger Motor Car Co. He said that the public was demanding of the motor car, *first*, more range of adaptability; *second*, smoothness, and *third*, less noise. The six cylinder motor is perfectly balanced, and thus reduces the vibrations in the car considerably, compared with the four, but when the six cylinder car is running slowly on high speed gear the explosions of the motor are so far apart that distinct vibrations are set up in the car. To remedy this either a heavier crank must be used, which means added weight, or more cylinders, which give less weight. It would seem that the twin four would be the next logical step after the 6 cylinder motor, but Mr. Walker pointed out that the eight cylinder motor is not balanced, and thus does not do away with vibrations in the car. In automobile design weight is a serious consideration. The twelve cylinder motor saves in weight in cylinder, piston, connecting rods, crank, crank case, and fly wheel.

UNIVERSITY OF COLORADO

At a meeting of the University of Colorado on November 11, C. H. McClintock, Student Member, gave a talk on the Arkansas Valley Plant of the American Smelting and Refining Company from his summer vacation work with the company.

At a joint meeting of the Branch and the Civil Engineering Society, on December 9, Ejnar Posselt, Mem.Am.Soc.M.E., gave an illustrated talk on Cement Manufacture.

UNIVERSITY OF KENTUCKY

At the December meeting of the University of Kentucky Student Branch, the members assumed the attitude of salesmen with the idea of selling a 300-h.p. unit for a manufacturing plant to three "buyers" representing the plant.

To this end, the class was divided into five sections, representing the Curtis turbine, direct connected to a generator with individual motor drive; the Parson turbine, direct connected to a generator with individual motor drive; the Corliss engine, belted to load; a cross compound engine, belted to load, and the Nordberg Uniflow engine, belted to load.

Each side endeavored to show that they had the specific unit which would fill the requirements in the most economical manner rather than that their competitors' machines were defective, and it was with difficulty that the "buyers" were able to decide, but finally, they "let" the contract to the salesman of the Curtiss turbine.

UNIVERSITY OF MINNESOTA

The regular meeting of the Minnesota Student Branch for December was held December 11, 1915. The speaker was Prof.

J. J. Flather, of the Mechanical Engineering Department, and his subject was "Engineering Education in England." The facts for his speech he had obtained, first hand, while pursuing special studies in engineering in Great Britain for the past year. While there, he visited the English engineering schools and also talked with employers of young engineers.

He told his audience that they should be thankful that they had the opportunity for studying their profession here in America. The opportunities of getting a higher engineering education in England are exceedingly limited; the cost is high, the shop requirements heavy and the results in the theoretical part of the work tend to be superficial. The courses, he said, do not appear to be developing industrial leaders, but rather mediocre foremen and designers.

Beside the regular meeting of the society, there were two meetings open to the whole college. The first of these took place Saturday, November 20, 1915. The speaker was Prof. F. B. Rowley, of the Drawing Department and his subject was "The Mechanical Equipment of Buildings." With the help of lantern slides, he explained the mechanical equipment of the Biology Building, one of the newest buildings on the University Campus. The second was a steropticon lecture furnished by the S. K. F. Ball Bearing Company. A. W. Holmberg, of the Post-Senior Mechanical Class explained the slides.

UNIVERSITY OF MISSOURI

A meeting of the University of Missouri Student Branch was held on November 11. A. C. Lanier, professor of Electrical Engineering gave an interesting and instructive address on Present Requirements and Characteristics of Motors in Industrial Application. In his talk, he discussed fully the main kinds of drives, and the work for which each is adapted, pointing out the advantages of the electric drive, over that of other drives for many kinds of work, where formerly other drives have been used. Also he discussed the types of loads, and the factors determining the selection of motors for these various loads.

The largest meeting of the society took place on November 19, at which E. B. Morgan, safety engineer for the Commonwealth Steel Company, gave an illustrated address on the Relation of the New Efficiency Problem, Industrial Safety, to the Engineer. He told how his company had found that the so-called guarded machinery, as usually found in practice, was not only poorly designed and expensive but also failed to fulfil efficiently the purpose for which intended, namely that of reducing the number of accidents. Therefore under his direction a scientific study of the cause and remedy for the large number of accidents occurring annually in the plant was undertaken. The result is that the number of accidents has been materially decreased, and a large sum of money, which formerly was paid out for accident and death claims, is now saved by the company. Also in applying the remedies necessary for safety, it has been found that the efficiency of the plant has been increased in many instances by these changes. Some of the particular safety appliances mentioned and illustrated on the screen were the use of locks on all motor switches to lock the switch while repairs are being made on the machine, so that there will be no danger of anyone starting the machine while a repairman is at work; the use of especially designed goggles by the workmen, wherever the work is of such a character as to endanger their eyes; the construction of suspended passage ways for repair, oiling, etc., of overhead motors, belt drives, etc.

VIRGINIA POLYTECHNIC INSTITUTE

A meeting of the Virginia Polytechnic Institute Student Branch was held on November 27. A paper was presented by Messrs. C. F. Lawson and C. E. Parker on the Development of the Mechanical Stoker. An enthusiastic discussion followed the reading of the paper and many features of the stoker were commented upon.

It was announced that at future meetings, papers would be read on Low Water Alarms by Messrs I. N. Moseley and R. R. Connelly; Superheaters by Messrs W. R. Ellis and R. M. Hutchinson and the Diesel Oil Engine by Messrs. W. L. Cogbill and H. A. Davenport.

Mr. Kavanaugh, chairman of the Branch, announced that arrangements had been made for a series of lectures to be given in the near future by the following men: A. Kearney, Asst. Supt. of Motive Power, N. & W. Ry., who will speak on Train Resistance; C. M. Janelle, associated with the Baker Pelloid Company, who will speak on Valve Gears; C. H. Quin, chief electrical engineer N. & W. Ry., who will speak on The Development of Electrical Motive Power on the N. & W. Ry.; and F. H. Cunningham, associated with the Standard Stoker Company, who will speak on Mechanical Stokers.

WISCONSIN UNIVERSITY

At a meeting of the University of Wisconsin Student Branch on December 2, Mr. Barnett gave a talk on the substitution of aluminum for cast iron in automobile engine pistons. Mr. Barnett pointed out clearly how the vibrations of the engine would be decreased by making the reciprocating parts of this lighter metal. He also stated that the increase of cost of material would be reduced partly by the decrease in cost of machining.

WORCESTER POLYTECHNIC INSTITUTE

At a meeting of the Worcester Polytechnic Student Branch on November 5, F. L. Fairbanks, Mem.Am.Soc.M.E., Chief Engineer for the Quniey Market Cold Storage and Warehouse Co. of Boston, spoke on Some Experiments in Lubrication. He has under his supervision a line of engines, compressors and pumps giving a service of peculiar interest to engineers in that the service is a continuous one. He showed by description and sketches how, by means of especially designed bearings and by special methods of lubrication, the plant service had been improved to a point where, for some of the machines, the steam throttle had not been closed for a period of many months. He remarked that some of the oilers employed had never seen the engines at rest during their period of service. His lecture dealt especially with such bearings as those of the main machining and design were illustrated.

At the regular meeting of the Student Branch of the Worcester Polytechnic Institute on December 3, Hartley W. Bartlett, a Patent Attorney in Worcester, presented an exceedingly instructive paper on Inventions and the Patent System. To begin with, the speaker traced briefly the historical development of our Patent System and mentioned the essential features of its operation. He then took up the subject of patentable and non-patentable inventions.

The procedure necessary for obtaining a patent was then explained, the first step being the filing of the application, which contains: The petition; complete description; new features of invention; claims for the invention and reasons why the patent should be granted; oath of form. It was pointed out how difficult it is to frame the application, making the claims as broad and inclusive as possible and the specifications extremely definite, clear and proof against infringement. After the application with drawings, etc., is filed in one of the divisions of the Patent Office, it is considered by the Examiners.

After this discussion, Mr. Bartlett took up the matter of Interference and explained the difficulty of proving "priority of invention" and how some inventors are "beaten out" of their invention and patent by unscrupulous men. Infringement and court procedure in such cases was next treated and mention was made of the discouragement and failure which often comes to inventors without large means who are forced to fight large corporations for patent rights and privileges. The speaker pointed out one important difference in the Patent Laws of this and other countries in that owners of American patents are not required to "work" them while owners of most foreign patents may be compelled to do so.

A discussion of the preparation for entering Patent Law was then taken up including: Course in Mechanical Engineering; Civil Service Examination and position as Examiner; Study in night law school during work as Examiner; Admission to Bar and entrance into practice. When asked about the remuneration of inventors in general Mr. Bartlett said, "If you want to become a millionaire, go into business."

ACCESSIONS TO THE LIBRARY

This list includes only accesions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

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EMPLOYMENT BULLETIN

Beginning with this issue of the Journal the notices appearing in the Employment Bulletin are published in a form which indicates at a glance the classification.

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.

399 SALESMAN on electric clock system, with acquaintance among New York architects and contractors. Salary commission basis. Name confidential.

401 SALES ENGINEER of highest merit. Must show excellent past record and be personally and closely acquainted with the engineering profession from the operating and consulting end in Greater New York; must be familiar with boiler plant practice and be a man of good personality and a high grade salesman.

402 ASSISTANT FOUNDRY FOREMAN for manufacturers of farm implements and heavy machinery. Must be man of tact and ability. Location Pennsylvania.

405 INSTRUCTOR in machine design; desire young engineer having had some teaching and practical experience. Send references, recent photograph, full statement of training and experience. Location Middle West.

406 INSTRUCTOR in mechanical engineering laboratory practice and steam engineering. Prefer young engineer with some teaching and practical experience. Send references, recent photograph, full statement of training and experience. Location, Middle West.

407 SALES ENGINEER for New York concern manufacturing fans, blowers and power house equipment.

408 SALESMAN, experienced, competent to sell refrigerating machines in Philadelphia and within a radius of 100 miles of Philadelphia.

409 VALVE AND FITTING DESIGNER AND CHECKER with large firm; good future to man with experience who is willing to hustle and work hard; others need not apply. State experience in full, salary expected and references. All correspondence will be strictly confidential.

413 DRAFTSMAN on box machinery to work under instructions. Maximum salary, $25. Location, New York.

417 DRAFTSMAN on jigs and fixtures. Salary, $20—$25. Location, New York.

418 Detail Draftsman at salary of about $18. Location, New York.

419 All around Draftsman on reinforced concrete structures. Possibility of having to go into field to complete work. Salary, $25 to $35. Location, New Jersey.

422 Inspector on installation of machinery; young technical graduate familiar with construction work, mill wright work and general factory maintenance.

425 Draftsman on automatic machinery. Salary depends on man. Location, New York.

426 Assistant in Research Work. Recent graduate as assistant in work of assembling figures and results. Location, New York.

427 Draftsman experienced in evaporator and drying work; not necessary that he be a designer. Apply by letter stating experience and salary expected. Location, New York.

431 Assistant Manager of phosphate mining company; both electrical and mining engineer; must be familiar with power house practice and thoroughly experienced in both gas and Diesel engines. Salary $200 per month. Position carries with it house to live in, electric light and water free. Location, Florida.

432 Engineer and Draftsman for work in the engineering department of paper manufacturing company operating four fine writing and cover mills; work includes design of buildings and machinery, layout of mill equipment, testing of power equipment and machinery, investigations, etc. Salary between $1200 and $1800 per year, depending upon capability of man. Opportunity for advancement.

433 Engineer capable of taking hold of design of new foundry under direction of engineer of company manufacturing cast iron and water pipe. Location, New Jersey.

436 Junior Engineer with some shop experience, capable of designing tools and doing ordinary mechanical drawing. Salary $100 to $125 a month. Location, New England.

437 High Grade Draftsman familiar with machine design. Location, New York.

438 Assistant Superintendent for plant consisting of foundry employing about 90 men and factory with about 700 men and 60 women. Want primarily a shop engineer, first-class mechanic with experience in designing machine tools, jigs, fixtures, etc., and manufacturing small parts on an absolutely interchangeable basis. Prefer man with experience similar to manufacture of sewing machines and cream separators. Salary depends on earning capacity of man. Location, New York State.

442 Chief Draftsman on design and installation of machinery. Location Jersey City, N. J.

443 Draftsman for same company as 442. Salary $20 to $25.

446 Draftsman, experienced and thoroughly reliable, with practical shop experience for designing automatic machines for paper products. Salary $1,200 to $1,500. Location, New York.

447 Detailer for automatic machines, quick and reliable, with practical shop experience. Location, New York.

449 Designer and Superintendent of installation on power work, electrical and steam. Salary about $1,800 a year. Location, New Jersey.

450 Machine Tool Draftsman. Salary $150. Location, New York State.

451 Draftsman on steam power plant piping layout and heating system. Man experienced in the piping work. Salary $25. Location, New York City.

452 Purchasing Agent for Connecticut concern manufacturing recording instruments. Location, Connecticut.

453 Expert Accountant for company listed under 452.

454 Building Estimator, capable and experienced in the purchase of building material. Young college man preferred. Excellent opportunity. Location Middle West. State experience in full, salary received, age and references in first letter.

455 Manager for creosoting plant in Florida; one experienced in this line of work. Salary $100 to $125 a month, including house, light, water, etc.

456 Assistant to Superintendent of Employment; young university graduate to develop a systematic plan for engaging, training and record of progress of employees; one who has made a study of psychology or at least with clear conception of the requirements of such a position. Location, New York.

457 Inspector of Materials and Supplies to work under the supervision of the head of bureau of tests of New York concern manufacturing paper products; to accumulate data which will form basis for research work leading to standardization of grades of paper and other materials used in manufacturing processes. One or two years experience in paper industry would be especially helpful. Location, New York.

458 Young Technical Graduates, preferably in mechanical engineering, to enter manufacturing department under direction of betterment department and be trained for positions of responsibility in factory and planning room of paper products company. Location, New York.

MEN AVAILABLE

The published notices of "men available" are made up only from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

A-1 Superintendent, age 33, first-class toolmaker and machinist, experienced in builders' hardware, small machines, instruments, speedometers, etc., six years with present concern, and who has held positions from toolmaker to superintendent desires to make a change. Location Eastern States, preferred.

A-2 Professor of Mechanical Engineering in a Canadian University, technical graduate of A-1 U. S. Institution, both M. E. and E. E. training, has held responsible position in large manufacturing plant as well as important U. S. government post as engineering expert, also has had four and one-half years successful teaching experience, and is author of engineering text books and numerous technical articles, desires teaching position in U. S. college.

A-3 Translator. Professor of applied mechanics in the University of Liége, Belgium, Mem.Am.Soc.M.E., Inst. of Mech. Engrs. and Iron and Steel Institute, is available for work in translation into French, catalogues or technical publications of American firms.

A-4 Works Manager, age 40, with large and long established company manufacturing power equipment, twenty-two years general shop experience, having handled men for fifteen years, experienced in large production, having supervised from fifteen hundred to eighteen hundred men, desires to make a change.

A-5 Position Wanted by student member, Columbia University 1915 M.E., in or around New York, which offers opportunity for advancement and good engineering experience, also fair salary to start. At present employed.

A-6 Executive. Member with wide experience in machine shop, grey and malleable iron work, desires business connection in an executive capacity with an established manufacturing concern.

A-7 Assistant to Consulting Engineer. Technical graduate, Junior member, age 26, five years assistant to consulting engineer, has been in responsible charge of general engineering work, tests, investigations and reports, desires position along similar lines or with public service company offering attractive opportunity.

A-8 EXECUTIVE. Graduate M.E., Cornell 1906, age 32, married, four years experience testing and determining unit costs of steam, air, water, electricity and refrigeration, advancing to chief of tests. Four years as chief engineer of lime manufacturing plants, specializing in combustion engineering and design of elevating and conveying machinery; one year as purchasing engineer of same company, has reached the limit of present position and desires to make a change, following same lines of purchasing, engineering and efficiency study work. Salary $4000, with promise of advancement.

A-9 ADVERTISING MANAGER. Graduate mechanical engineer, age 31, thoroughly experienced in modern publicity work as applied to products of a mechanical nature, is open for position as advertising manager. Replies are solicited only from high grade firms that believe in clean cut, dignified methods, and are willing to pay a suitable salary for capable services.

A-10 EXECUTIVE. Member, age 35, technical graduate M.E., twelve years experience in general engineering work, civil, mining, and mechanical, steel plant and general construction, estimating, office and field work, wishes to locate a position in which broad engineering experience together with ability to handle men will be required. At present employed.

A-11 PRODUCTION ENGINEER. Member, age 34, fourteen years experience, seven in charge of drafting room, and successful in working out original problems of design from a manufacturing standpoint with a view of interchangeability and low cost of production, desires similar position. At present employed as mechanical engineer with large corporation.

A-12 EXECUTIVE FOR SMELTER OR MINE PLANT. Mechanical engineer, age 35, specialist in the design and construction of smelters, mine plants and mills with machinery and appliances, also conveying machinery, experienced in acid plant construction. Fourteen years with mining-smelter companies and manufacturers, wishes responsible executive or engineering position with a mine or smelter company. Has had executive and sales experience. Now engaged in New York and would like to locate there or in vicinity.

A-13 ENGINEER ON OIL ENGINES. Member, University training with extensive experience in the design and construction of marine and stationary four and two-cycle engines; has held positions with a leading German firm as co-worker in the development of the marine type into a commercial form; prepared to turn out simple and economical engines with experimental stage eliminated. Desires position as executive, chief engineer, manufacturing superintendent, or assistant engineer of tests with a first-class manufacturing concern producing oil engines.

A-14 SALES ENGINEER. Technical graduate, twelve years selling experience, especially Government work, at present in charge of Washington, D .C. office of large machinery manufacturer and desires similar position in New York.

A-15 PRODUCTION ENGINEER. Associate-member, M.E., age 38, expert in interchangeable manufacturing, sheet metal stamping and evolution of shapes; economic production of duplicate parts, light mechanical devices and machinery. National reputation as mechanical expert and consulting engineer, author of numerous standard mechanical test books; developer and perfector of machines and devices for commercial efficiency and success, desires position as production engineer where ability to eliminate costs, operations and intricate mechanisms and effect maximum efficiency and output at minimum cost will earn $4000 per year, and more when results justify increase.

A-16 SALES ENGINEER. Graduate M.E., age 31, well posted on pumps and pumping machinery of all types, oil, gas and steam engines, drawing room and shop practice, sugar house work in Mexico and sales engineer in Brazil, desires permanent employment with reliable firm either in sales, office or shop. At present employed as salesman and expert on farm machinery.

A-17 CHIEF ENGINEER. Member, Cornell M.E. graduate, with several years successful experience as chief engineer and manager, and thoroughly trained and successful in shop, office and development work, desires a responsible position.

A-18 WORKS MANAGER. Member, age 37, technical education, wide experience in power plant design, construction and operation, power plant economy, piping, building construction and factory engineering, desires position as works engineer or mechanical superintendent.

A-19 CHIEF DRAFTSMAN, MECHANICAL ENGINEER AND SUPERINTENDENT. Member, technical education and fourteen years general engineering experience, perfectly familiar with design, construction and operation of plants manufacturing cement, coal mining and cooking plants; has made an especial study of elevating and conveying machinery in connection with cement making and coal handling. Has held positions as chief draftsman, mechanical engineer and superintendent. Now employed but to avoid traveling desires to get in touch with large company where experience and ability may gain him a permanent position.

A-20 ASSISTANT TO SUPERINTENDENT. Associate-member, B.M.E., age 29, three years experience inventorying power plants, factory equipment, and buildings of two large plants in the South, past four years employed as mechanical engineer at an Eastern plant, has made all machinery layouts and superintended the installation of all of the machinery in plant, looked after up-keep, installed a modern cost-keeping system, and acted as general assistant to superintendent. Salary, $2400. At present employed.

A-21 SUPERINTENDENT. Member, Stevens graduate, age 38, married, desires to make a change. Has had two and one-half years experience in shop and drafting room, steam and electric machinery and air compressors; three and one-half years designing and building electrical apparatus for naval vessels; nine years as assistant superintendent and superintendent of inspection department of two large casualty companies.

A-22 MANAGER, SUPERINTENDENT OR SALES ENGINEER. Member, graduate M.E., Lehigh University, several years in management of mechanical and purchasing departments of railroad, coal mining, and industrial corporations. Also extensive experience as sales engineer in railroad equipment. Good organizer and executive, qualified to fill position of manager of an industrial plant or coal mining company, or superintendent of motive power of a railroad. Can successfully represent manufacturers of machinery, power plant equipment, iron and steel.

A-23 SUPERINTENDENT AND WORKS MANAGER. Associate member, age 45, Scotch, with long experience as foreman, superintendent and works manager in large jobbing shop doing machine, smith and sheet iron work and also well versed in motor vehicle construction, desires to change position.

A-24 EXECUTIVE. Mechanical engineer, technical graduate and member with broad shop, mill and power plant experience, desires important executive position with large progressive concern.

A-25 SHIPBUILDING ENGINEER. Member, technical graduate, age 36, experienced in design and construction of structural steel work, machine tool, shop layout and arrangement of machinery, efficiency management, accounting and costs, works management, planning and routing, orders and stores, also experience as sales engineer, desires to become associated with a shipbuilding concern or an allied industry. Location preferred New York or Philadelphia.

A-26 POWER PLANT ENGINEER. Student member, 1915 graduate in M. E., wishes position along lines of power plant engineering. At present employed with manufacturing concern.

A-27 SUPERINTENDENT. Member, over twenty years experience along engineering lines; twelve years shop practice and eight years office. Experienced in locomotives, cars, boilers, engines, special machinery, shop layouts and structural work. Has held positions from machinist to superintendent of construction. At present employed.

A-28 Superintendent. Member, graduate engineer, age 32, possessing exceptional executive ability, ten years experience in shop work, drafting, erecting, operating, purchasing and selling; familiar with steam, gas and oil engines, and refrigerating machinery, desires a permanent position as superintendent, or engineer with reliable company near Philadelphia. Salary $3000. Temporarily employed, but available January first.

A-29 Superintendent. Member, technical graduate, age 37, fifteen years office and shop experience as designer, engineer and superintendent in United States and abroad, is open for engagement. Broad experience in designing, manufacturing and testing special machinery, turbines, automatic railway air connectors, etc. Thorough knowledge of German. At present employed.

A-30 Works Manager. Member, M.E. and E.E., analytical mind, initiative, originality, balanced by commonsense, knows how to get larger output, lower costs, better information, greater profits, broad experience in machinery, metal and wood manufacturing, designing, production, efficiency, costs, accounting, auditing, management, desires position as works manager.

A-31 Sales Engineer. Mechanical engineer, graduate Columbia 1912, experienced in design and construction work, desires permanent position, preferably in sales or where there is a chance to work into sales or commercial end of business. Location immaterial.

A-32 Sales Engineer with Patent. Member, recently granted U. S. patent (not yet issued) on improved shop appliance for which there is a wide and profitable market, wishes to arrange for manufacture and exploiting with established concern possessing ample facilities and resources for handling the business. Is thoroughly conversant with advertising and sales methods in this particular line, and capable of organizing and managing department which should be financially satisfactory to all concerned.

A-33 Research Engineer, Engineer of Tests. Mechanical and electrical engineer with scientific training, experienced in the organization of testing and research departments, and the construction of scientific laboratories, desires position, temporary or permanent, which requires the exercise of business judgment and executive ability, in addition to a knowledge of the fundamental sciences entering into work of this character. Has built and organized chemical, physical, electrical, metallurgical, metallographic and strength of materials laboratories, as well as laboratories for special research.

A-34 Chief Inspector. Mechanical engineer, age 27, wide experience in factory inspection, rating of plants, compensation work and guarding of machinery, desires position as chief inspector of mutual company. Salary, $1800.

A-35 Manager. Member, technical education, twenty-seven years practical experience on pumping machinery, compressors, pneumatic machinery, both design and construction, conducting power and efficiency tests, handling engineering correspondence, will accept position of engineer or manager, or other executive position with manufacturing firm or consulting engineer.

A-36 Junior Member, technical graduate, age 27, four years shop and about one year's drafting room experience, also special organizing work and in production department of company making centrifugal pumps and power plant auxiliaries. Salary, $1500.

A-37 Assistant to Consulting Engineer or Contracting Firm. Mechanical engineer with thorough technical training desires connection with consulting or contracting firm. Has had splendid experience in planning work for machine shops and in testing.

A-38 Inventor and Executive. Mechanical engineer, member, age 39, university graduate, twenty years experience in various engineering fields, inventive and executive ability, desires position, preferably in or around New York. English, French and German correspondent.

A-39 Metallurgical Engineer. Member has had extensive experience in design and operation of gas producers, foundry practice, manufacture of steel for ordnance, and expert in the properties of materials.

A-40 Manufacturers Representative. Member with office and wide acquaintance with manufacturers, public utility officers, consulting engineers and architects, desires to add to representation in Ohio, Buffalo, Pittsburgh and Detroit districts.

A-41 Works Manager or Assistant. Junior member, technical graduate, shop, selling and shop management experience, desires position as works manager or assistant works manager. At present in charge of manufacturing department of large plant building special machinery. Has reduced operating expense and cost of production.

A-42 Member, Stevens graduate, mechanical engineer, thirteen years experience design and construction steam electric plants, pumping stations, industrial works, heavy foundations involving pneumatic caisson method, reports and appraisal, also business experience, is open for engagement.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

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St. Louis: Edward Flad
Worcester: Paul B. Morgan

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and it will also be published in the February 1916 issue of the Journal.

ENGINEERING SURVEY

Wadkin propeller-shaping machine—Flow of air in round ducts—Swedish type Diesel engine—Propelling machinery, U. S. S. "Maumee"—Southwark-Harris valveless engine—Exponent m, expansion line, internal combustion engines—Gas producer air-steam ratio—Heat treatment of modern steels—Ghost lines in large steel forgings—Segregation and sponginess in ladle test ingots—Physical properties of hydraulically forged wrought iron and steel—High grade alloy steel at low cost—Carbon and physical properties of heat treated carbon steel—Plate fulcrum track scale—Gunite timber piles in tropical waters—Apparatus for measuring velocity of gases—Measurement of coefficient of cyclic variation—Power requirements for wire drawing—Engineering charts—Crankshafts for high-speed engines—Flow of superheated ammonia through orifices—Safety valve for ammonia compressors—Reversed heat engine as drying machine—Loss of heat from steam heated surfaces—Letters of James Watt—Artificial arm.

In 1912 was established a section of The Journal called at that time the Foreign Review. It included abstracts, at first quite brief and then somewhat longer, of articles in engineering periodicals printed in foreign languages only. In 1914 this activity of the Society, which from the start, if one may judge from letters received, met with the approval of the membership, was extended by the addition of a review of the proceedings of engineering societies. Finally, at a meeting of the Council on October 8, 1915, it was voted to approve the recommendation of the Publication Committee to include in The Journal a review of the world's technical press. In accordance with this resolution, the Engineering Survey will contain, in addition to the material as hitherto published, abstracts from engineering publications in the English language. This feature will be developed gradually, beginning with the publication of a few abstracts in each issue selected with a view to placing on record the more important developments in mechanical engineering. It is the desire to arrive finally at a publication which would cover the field of mechanical engineering as completely as may be desirable for all practical purposes. A new feature to which attention is called is a list of the more important engineering articles published at the end of the Engineering Survey. The Library receives now close to 1000 publications in more than a dozen languages, and an attempt will be made to keep this list as up-to-date as possible and as complete as the space available will permit.

THIS MONTH'S ARTICLES

In the section, Aeronautics, is described the Wadkin Propeller Shaping Machine, really a copying machine having some peculiar features of its own.

In the next section, Air Engineering, is given an abstract of a discussion of Phenomena Accompanying the Flow of Air in Round Ducts, containing among other things some data of interest in connection with test of fans by means of Pitot tubes.

The section on Internal Combustion Engineering is of particular interest. It contains a reference to a Swedish type Diesel engine built in this country; a description of the propelling machinery for the U. S. S. Maumee, and of the Southwark-Harris valveless engine, the latter a very interesting type in many respects. A discussion of the Determination of the Exponent in the Equation for the Expansion Line of Internal Combustion Motors is abstracted from a German periodical. In the same section is abstracted an article on the maintenance of exact proportions between draft and steam admitted under a producer grate, as well as losses from incorrect driving.

In the section on Materials on Construction will be found an abstract from an advance publication of a paper by Prof. J. O. Arnold on The Cause and Effect of Ghost Lines in Large Steel Forgings, of particular interest because the author has had a somewhat unusual opportunity to ascertain the exact nature of unforged ghosts. Another paper on the Segregation and Sponginess in Ladle Test Ingots abstracted from the Bulletin of the American Railway Engineering Association is of interest in that it shows why test ingots taken from the same batch may give entirely misleading results, and next in that it recommends additions to rail specifications covering shape and size for ladle test ingots as well as standardizing the methods of taking them. The Influence of Temperature and Mechanical Work in Hydraulic Forging on the Physical Properties of Wrought Iron and Steel is discussed in a paper by Dr. Fuchs abstracted from a German publication. A rather unexpected fact found during the tests described in that paper is that the force and work required for forging, instead of gradually decreasing with the increase of temperature of forging, increases at first and does not begin to decrease until about 850 deg. cent. A development of high grade alloy steel at low cost, the chemical and mechanical relations of the carbides of iron and molybdenum and gunite coated piles for use in tropical waters, are some of the other articles abstracted in the same section.

In the section on Measuring Apparatus is continued from the December issue an abstract on apparatus for measuring the velocity and pressure of gases. There is also given an abstract of a description of a Plate Fulcrum Track Scale, a type representing in several respects a radical departure from the usual design of track scales.

In the section Mechanics attention is called to the article by Prof. J. von Rohonyi concerning the measurements of the coefficients of cyclic variation in the motion of prime movers. Other articles in the same section are a critical consideration of the factors affecting power requirement to be met in the manufacture of wire in drawing rods; a mathematical discussion of the apparent vagaries of performances of screw propellers on ships in actual service, and a reference to the Horseless Age engineering charts. The beginning of the abstract of a paper by P. M. Heldt on the Design of Crank Shafts for High Speed Engines is also given.

In the section on Refrigeration are abstracted from the Journal of the American Society of Refrigerating Engineers two articles, one on the Flow of Superheated Ammonia Through Orifices, giving among other things two plots from which, knowing the head pressure and the degree of superheat, the volume of a pound of superheated ammonia at the condition in the orifice can be read. The other article describes an improved ammonia safety valve.

The Loss of Heat from Steam Heated Orifices, and the Reverse Heat Engine as a Drying Machine are discussed in the section on Thermodynamics.

Aeronautics

The Wadkin Propeller Shaping Machine.

It is a curious fact that the particular part of the mechanism of an aeroplane in which the very highest finish and the utmost possible delicacy are required, should have been carried out purely by hand and left to the touch of individual workmen as has hitherto been the case in regard to aeroplane propellers. This anomaly may have been due to the varying nature in grain, hardness and specific gravity of the timber employed for this purpose. Still, where quickness of output is essential and the article is strictly standardized, great advantage might be derived from the use of mechanical propeller shaping machinery. Such a tool has been placed on the market in England by Wadkin & Co. (Fig. 1).

The machine will handle propellers up to 12 ft. diameter and will produce an exact fac-simile of the original placed into the machine. This "original" consists of a single blade only, together with the hub, which is mounted on a mandrel in a horizontal plane opposite to a carriage arranged to slide longitudinally on a bedplate. This carriage is adapted to support two pivoted arms, the lower of which carries the original roller, and the top one, the cutterblock mounted on a reciprocating headstock. At their opposite ends, the two pivoted arms are connected by a link which is adjustable to enable the size of reproduction to be varied if desired. The headstock supporting the two arms is reciprocated across the bed by means of a crank motion so that the cutters will traverse across the work. As each end of the stroke is reached, the carriage is moved longitudinally 1/8 in. so that cutting takes place both on the forward and backward stroke across the work, thus saving considerable time. The cutterblock is fitted with 12 cutters, six on the front and six on the back. The drive is by means of a flat endless belt running over a two-step pulley mounted on ball-bearings and carried by a bracket fixed to the sliding headstock.

The "original" consists of one blade and the hub portion and is made preferably of cast iron, identical in shape with the blade to be formed, thus enabling existing gages and templates to be used to insure accuracy of the original. It is essential that the shape of the blade should be kept accurately along its longitudinal edges, so that means must be provided to prevent the original roller from falling abruptly. A few holes should be drilled and tapped along the edges of the original to permit of screwing to it a wooden guide shaped to enable the roller to run down a slight incline. When one side of the blade has been cut, it is only necessary to reverse the work and also the original in its supports.

The feature of the machine is that an old broken propeller may be used as the "original" and an exact duplicate made from it. (*Aeronautics*, vol. 9, no. 108 (new series), p. 315, November 10, 1915, 2 pp., 2 figs. *d*).

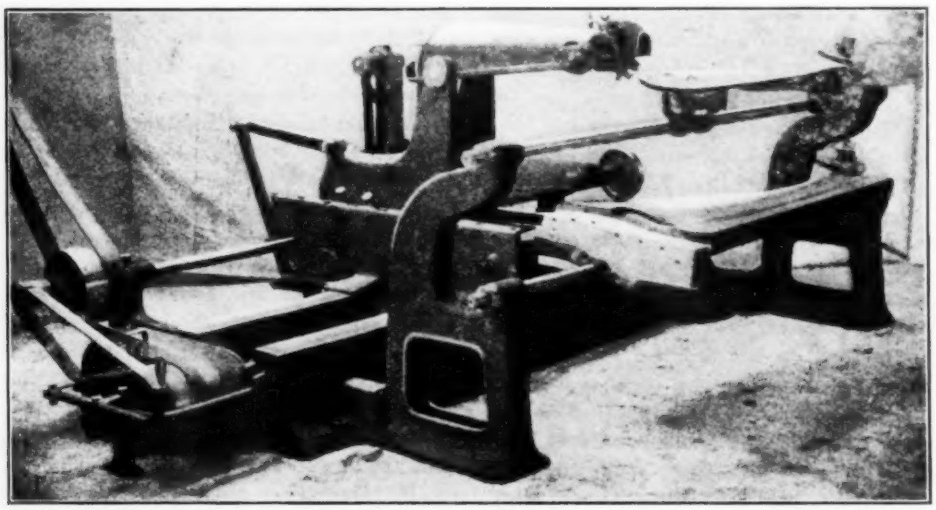

Fig. 1 Wadkin Propeller-Shaping Machine

Air Engineering

Some Peculiarities of Air Flowing in Round Ducts

Prof. J. E. Emswiler

Discussion of phenomena accompanying the flow of air in round ducts.

The author begins by a discussion of the distribution of velocity across the section of pipe. The assumption that the air is moving fastest near the center and slowest at the perimeter is true only for a section of the pipe located at a considerable distance from the fan, or from an elbow, or any source of disturbance of the stream line flow. In other words, the condition of high center velocity prevails when the flow is relatively quiet, but at the section very near the fan, it is found that the velocity at the center is nearly equal to that along the walls, while the maximum velocity occurs between the center and walls. Tests made in the mechanical laboratories of the University of Michigan with a very long pipe (100 feet long) showed that maximum divergence between the center and wall velocity occurred at the greatest distance from the fan.

Connected with this difference in velocity distribution across the pipe at different distances from the fan is the effect on the frictional resistance. Tests in the University laboratories have shown that if observations are made at three points along the length of a long straight pipe, one near the fan, one near the end of the pipe, and the third midway between the first two, the frictional resistance of the first section is appreciably higher than it is in the second section. The reason for this difference most likely lies in the velocity distribution in the tube sections, as the frictional resistance of air moving in a pipe is due to two causes; *first*, the friction of the air against the walls of the passageway, and, *second*, the friction of the particles of air sliding or rolling upon each other, which latter is due to the fact that all the particles do not

move at one speed. Of the two causes of loss the first is the greater. The *average* velocity of the air is the same at all points along the pipe but the average velocity of the air which comes in contact with the perimeter of the pipe is greater near the fan because of cross currents; hence, the pipe friction proper is greater in that part of the pipe near the fan.

The flow of air in a duct is not symmetrical, as the maximum velocity may be considerably greater on one side of the pipe than on the other; in fact, the place of maximum velocity in a pipe may travel in a screw path along its length. Ultimately this corkscrew motion will die down, but within the limits of the length of the customary test pipe which is about twenty diameters, such a movement of the air is nearly always present; hence to obtain accurate data for the calculation of average velocity, it is necessary to traverse the pipe on two diameters at right angles.

When a fan is tested by means of a Pitot tube placed in a test pipe the tube should be located about five-eighths of the distance from the fan to the end of the test pipe. The static pressure is then a measure of the friction in the test pipe lying beyond, and it might be thought that this would furnish a comparatively easy means of determining the friction coefficient of pipes. Actually this is not quite so. The total friction effect of a section of pipe discharging freely into the air is made up of two parts: *first*, the normal friction of flow within the pipe, and *second*, the exit loss at the point of escape. The latter may be small for a pipe whose discharge end is perfectly smooth, but the least little obstruction around the edge seems to cause an abnormal increase in loss (a similar or much larger obstruction placed much further back in the pipe has far less influence on the friction loss).

The following tests were made to illustrate the foregoing statements: Air was delivered through a 7 in. test pipe by a small Buffalo blower operated at constant speed. The Pitot tube was located above five-eighths the length of the pipe from the fan. With no obstruction at the end of the pipe a certain static pressure was observed. Then a screw-driver with a wooden handle about 1¼ in. in diameter was laid in the pipe 18 in. from the end. This obstruction increased the static pressure at the Pitot tube 15 per cent. Then a ruler ⅝ in. wide was placed diametrically across the pipe, first entirely across, and then extending partially across by varying amounts; the effect was to increase the static pressure above that when the exit was unobstructed, to the extent of from 10 per cent, when the percentage of obstruction was 0.4 per cent, to 200 per cent, when the percentage of obstruction rose to 11.3 per cent, which shows that an obstruction at the end produces a vastly greater loss than one placed in the pipe some distance from the end. (*The Michigan Technic,* vol. 28, no. 3, p. 204, October 1915, 3 pp., *et.*)

Internal Combustion Engines

Swedish Type Diesel Engine.

The article briefly describes and illustrates the Diesel engine manufactured by the McIntosh & Seymour Corporation of Auburn, N. Y. This Diesel engine is essentially that of the Aktiebolaget Diesels Motorer, Stockholm, Sweden (*The Iron Trade Review,* vol. 57, no. 21, p. 988, November 18, 1915, 1 p., 2 figs. *d*).

Description of Main Propelling Machinery for the U. S. S. Maumee, Lieutenant C. W. Nimitz, U.S.N.

The article describes the main propelling machinery for the U. S. S. Maumee (which was inspected on one of the excursions of the members of The American Society of Mechanical Engineers at the Annual Meeting, December, 1915). The U. S. S. Maumee is one of the twin-screw fuel ships authorized by the Naval Appropriation Act of August 22, 1915 (her sister ship is the *Kanawha*).

The Maumee has as propelling machinery two Diesel engines of 2500 b.h.p. each. Each main engine, which is built to turn outboard when going ahead, drives the following attached auxiliaries (described in the paper): Three high pressure air compressors for fuel injection and for charging air-starting bottles; three scavenger compressors for cylinder scavenging; two salt-water pumps for cooling all water jacketed parts of engine except pistons; one fresh-water pump for piston cooling; one lubricating oil pump for thrust block, main, crank pin and cross-head bearing lubrication; two general service water pumps for fire, bilge or sanitary purposes; twelve mechanical lubricators for cylinders and for minor bearing lubrication; one fuel oil supply pump for pumping fuel from ship's bunker tank to engine supply tanks; six fuel oil measuring pumps for supplying fuel to cylinders from engine room tanks; one speed governor; one tachometer; and one revolution counter.

For purposes of starting, compressed air at about 650 lb. per sq. in. from the air-starting bottles is led to those cylinders whose cranks are in the proper position for running in the desired direction. After the engine starts to run, starting air is admitted to each cylinder from 10 deg. past top center to 85 deg. past top center, until the engine has obtained sufficient speed for fuel admission. This speed is usually obtained in a very few revolutions. The operation of the reversal consists merely in cutting off all fuel from the engine, which causes it to stop very quickly and then to start in the reverse direction by compressed air as described above. (*Journal of the American Society of Naval Engineers,* vol. 27, no. 4, p. 794, November 1915, 27 pp., 5 figs. *d*).

Southwark-Harris Valveless Engine

One of the weak points in existing Diesel engines is that ice cold air is admitted at high pressure into the hot working cylinders to reverse or start up. Air stored in bottles or tanks at 600 to 1000 lb. per sq. in., when expanded through a valve, drops in temperature below the freezing point and its entering a cylinder heated to a high degree may be the cause of cracked cylinders, cylinder heads, and pistons. This is especially true in the case of marine engines when a vessel is coming into port after perhaps several hours or even days of continuous running in one direction with its cylinders and pistons heated to a high degree. To berth this vessel at the wharf possibly ten or fifteen orders may be rung down to the engine room in as many minutes. To carry out each of these orders, the engine is turned for a few seconds with this ice cold air and the next second after it is cut off, the contents of the cylinders are expected to be heated up over 1000 deg. This sets up very severe expansions and contractions, and may easily cause trouble.

The Southwark-Harris valveless engine is so designed as to never admit cold high pressure air into the working cylinders. It has a scavenging pump or low pressure compressor of the step piston type, that is, the piston of the scavenging pump is an enlarged extension of the main piston working in its own cylinder below the working cylinder. The scavenging cylinders are utilized for starting purposes, becoming immediately converted into air motors on movement of the starting lever either ahead or astern by the automatic cutting out of the suction and delivery valves. The air starting valves come automatic-

ally into play with the camshaft and keep the engine running by the action of the compressed air on the step pistons instead of on the main pistons. By continued movement of the handling lever the atomizer begins to open and the fuel commences to be supplied to the working cylinders, the engine still running, however, on compressed air in the scavenging cylinder without affecting the working conditions in the main cylinder, and thereby avoiding admission of the usual high pressure air into the working cylinder just at the time when it is necessary to build up the temperature.

Another peculiarity of the Southwark-Harris engine is that it has no valves in its cylinder heads. Each cylinder has only one cam working (the atomizer cam) when the engine is running in either direction. The use of the step piston for air starting does away with the necessity of air starting valves in the cylinder heads. The scavenging air is admitted to the working cylinder through ports in its circumference. The exhaust gases pass out through ports located opposite the scavenging ports and are so arranged that the piston opens and shuts them at the correct time during its travel. There remains, therefore, only one small opening to be provided for in the cylinder head for the admission of oil from the atomizer.

One of the disadvantages of the ordinary trunk piston type of Diesel engine is that it is necessary to give the pistons considerable clearance between the piston and the walls of the cylinder on account of the expansion of the pistons which is especially true in the case of a two-stroke cycle engine. This excessive clearance causes the piston in a trunk type of engine to take the side thrust of the connecting rod, which sets up a side flogging with its consequent noise. In the Southwark-Harris engine, this difficulty is avoided by the use of the step piston, the wrist pin being comparatively cool in the step or lower piston which practically does not expand; therefore, it can be made a nice fit in the lower cylinder and acts as a circular crosshead guide for the main piston. The main pistons can have ample clearance between themselves and the walls of the cylinder and let the rings do the work they are there for.

Another advantage of these step pistons when acting as scavenging pumps is that they draw in upon themselves and around the working piston on its outgoing stroke, a charge of atmospheric air for scavenging purposes. This air helps to cool the working pistons, and being in itself thus slightly heated, when the scavenging air enters the working cylinders, it is never as cold as is the case with four cycle engines. In the Southwark-Harris engine, it is possible to take off the inlet valves of the scavenging pump entirely, and owing to the peculiar design of the engine, it will still continue to run. Thus, if the inlet valves were to break down at sea it would not prevent the ship from working into port.

The Southwark-Harris valveless engine governs on a special and variable stroke principle controlled by the governor. Once the line is clear of air, there is always a solid stream of oil from the service tanks to the atomizers and the slightest movement of the pump plunger produces a corresponding movement of the column of oil so that if the stroke is increased by the governor, a corresponding additional amount of oil will be supplied. The oil is delivered from the service tank to the pumps under pressure supplied by the engine, making it immaterial where the service tank is located. As a result of such an arrangement the engine can be started in five seconds after having stood idle for a week or more. In fact, it will start under load like a steam engine.

The air under pressure, when allowed to act on the step pistons will turn the engine over even with its load on, so long as the engineer desires to do so, and after the momentum of the engine is built up, the oil can be given to the main cylinders, still, however, allowing the air to act on the step pistons. This in no way affects the working oondition in the main cylinder which is of importance for locomotives of interurban car service and especially in vessels, as it causes the ship to respond more quickly and with more certainty in a case of reversing from full speed ahead to full speed astern or vice versa.

The reversal of the Diesel engine by movement of the cam shaft on end requires considerable power to compress all the valve springs; in the new engine reversing is done by moving one rod on each cylinder so that however large the engine might be, practically no power is required. In fact, the Southwark-Harris engine is only of the Diesel type in its principle, the details of the engine being of an apparently novel design. (*Steamship*, vol. 27, no. 317, p. 109, November 1915, 5 pp., 1 fig. *d*).

Concerning the Exponent *m* in the Equation for the Expansion Line of Internal Combustion Engines

Dr.-Eng. Münzinger.

The experimental determination of the exponent m of the expansion line of internal combustion motors can be carried out best on a Diesel engine, because, due to the fact that the pressure variations occur in it in a more uniform manner than in other gas engines, observations suffer less from interference due to oscillations of the indicator. In the present investigation, which has been carried out in the Machine Design Laboratory of the Technical High School in Berlin, Dr. Münzinger used a 15 h.p. Diesel engine built by the Augsburg-Nurnberg Machine Works, and the Maihak indicator which is only slightly affected by frictional and mass forces, the purpose of the investigation being to determine the law of functional dependence of the exponent m on temperature.

From the usual equation of the expansion line, $p_1 v_1^m = p_2 v_2^m$ where p_1 and p_2 are specific pressures and v_1 and v_2, specific volumes, by the use of logarithms, the following expression is obtained for m: $m = \dfrac{\log p_1 - \log p_2}{\log v_2 - \log v_1}$

If, therefore, at a point of an expansion curve plotted on the logarithmic scale, a tangent is drawn, m can be determined by the tangent of the angle between the volume-axis and the tangent drawn. The magnitude of m is affected by the chemical composition and temperature of the mixture. The exponent of the adiabatic line is known to be $k = c_p/c_v$, where c_p is the specific heat at equal volume. For all gases, $c_p = c_v + 1.985/m$ and hence $k = 1 + 1.985/mc_v$ where m is the molecular weight. According to Langen, the following equation holds for carbon dioxide: $(mc_v)_m = 6.7 + 0.0026t$ where t is the temperature of the gas. Likewise, Pier found for steam $(mc_v)_m = 6.065 + 0.0005t + \dfrac{0.2}{10^6} t^2$ while for biatomic gases holds the equation $mc_v = 4.88 + 0.00106t$.

The value of the exponent is therefore affected by the conditions of carbon dioxide and steam, as well as by increase in temperature. Hence, the exponent m is smaller at the beginning of the expansion than at the end of the stroke. The cooling action of the cylinder walls has, as a result, the effect that the expansion line goes down more rapidly than the adiabatic line. It may be taken as established that the amount of heat conducted away per unit of time is proportional to the active area and is a function of the temperature difference between the walls of the cylinder and the gas. The coefficient of heat transmission, in its turn, depends on the density, the

state of motion, the temperature and the space distribution of the gas with respect to the surfaces of the walls. A good intermixture of the charge is, for example, very desirable from the point of view of perfect combustion, but comparatively poor when it comes to the carrying off of the heat. The piston velocity likewise affects the cooling action of the cylinder walls, since upon it depends the amount of time available for purposes of heat exchange. Finally, the expansion curve is made flat through after-burning of the charge. In Fig. 2A there are plotted over the *pv* diagram the values of *m*, as functions of the various positions of the piston. The gas temperatures are then determined for the various points of the diagram and

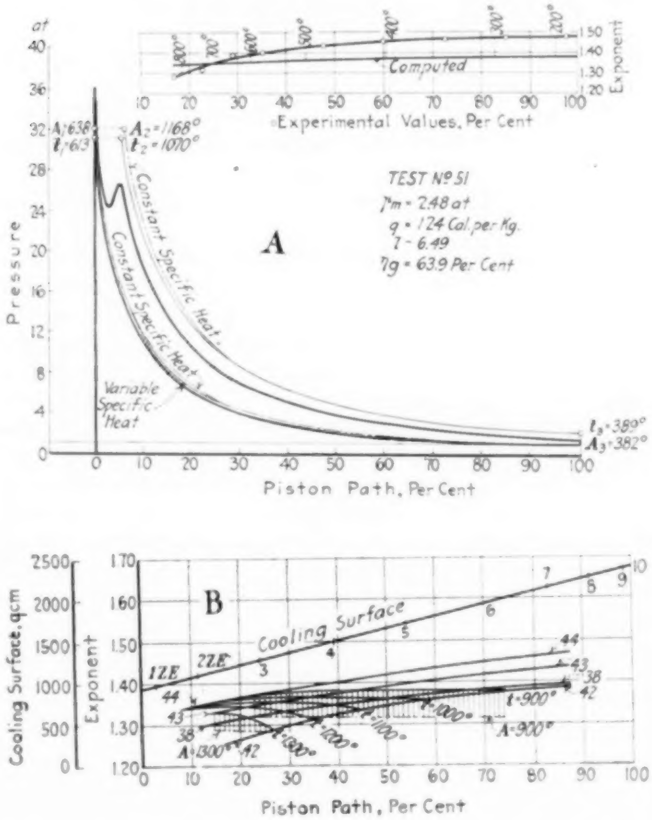

Fig. 2 Determination of the Exponent *m* in the Equation for the Expansion Line of Internal Combustion Engines

are calculated for these points under the assumption that no exchange of heat takes place. The values obtained are likewise placed on the diagram so that the influence of the walls and the after-burning can be seen from the difference between the exponents calculated and those obtained from the diagram.

One can see that the curves thus obtained intersect at low load; then form a flatter angle so that they run nearly parallel to each other, and finally when the load increases still more, intersect again. With average loads, the *mv* curve is nearly a straight line. In the extreme cases, it curves at the beginning of expansion and approaches the shape of a parabola. As the piston moves on and the cooling surfaces increase, the difference between *m* and *k* increases. In Fig. B are collected values of *m* from tests in which the *m* and *k* curves did not intersect. At high indicated pressures the curves thus obtained lie lower than at low pressures. The curves of equal temperatures, plotted in the same figure, run, for average temperatures, nearly parallel to the abscissae. If now the *k* curves be plotted for 900 deg. cent. and 1300 deg. cent. (1652 and 2372 deg. fahr.) it will be seen that at the lower temperatures the difference between *m* and *k* increases with the increase of the cooling surface and attains its maximum at 45 per cent of the piston stroke. On the other hand, at 1300 deg. cent. the *m* and *k* curves approach each other with the progress of the piston stroke because of the after-burning. In tests in which the efficiency approached the maximum, the curve for *m* was nearly a straight line. If at the beginning of the expansion, the curve of exponents approaches the shape of the parabola, the efficiency goes down, especially if at the same time there was a continuation of combustion during the expansion period. (*Die Ermittlung des Exponenten m der Expansionslinie von Verbrennungsmotoren*, Dr.-Ing. Münzinger, *Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 174, and *Dinglers polytechnisches Journal*, vol. 330, no. 22, p. 433, October 30, 1915. *e*).

Maintaining Gas-Producer Air-Steam Ratio, Franz Denk

The article discusses the importance of maintaining exact proportions between draft and steam admitted under a producer grate as well as losses from incorrect driving.

In particular, it discusses the methods applied for blowing air and steam into the producer. The main objection to using jet blowers is to be found in the irregular working of this apparatus because steam and air often cannot be blown in the fixed proportion required for the economical work of the producer, as sometimes, if enough steam is blown, the air is deficient and if enough air is forced in, it can be done only by blowing too much steam.

The author gives two curves (Fig. 3), showing the connection between the amount of air and steam blown, from tests made on the Koerting blower and the Eynon Evance blower. These curves show that if the necessary amount of steam is blown, the deficiency of air amounts to 25 per cent. At a steam pressure of 25.5 lb. there is enough steam, but an air deficiency of 19.5 per cent, while at a steam pressure of 40.5 lb. there is enough air but a steam excess of 28.8 per cent. These conditions are due partly to the variation of the back pressure and also to the fact that not enough attention is paid to the quality of the steam, notwithstanding the fact that the blower is an apparatus designed for dry saturated steam. There is a great difference in the velocity of steam and water flowing from nozzles under equal pressure, and the more water the mixture of both contains the less will be its velocity. When steam leaves the nozzle with 25 per cent moisture, the loss in velocity amounts to 13.6 per cent.

Superheated steam is blown partly to insure the proper quality of the steam and also to prevent the loss in coal due to having to convert the moisture in the wet steam into dry steam. The possible objection that the cost of installing a superheater may counterbalance the advantages in savings due to the use of the superheated steam is hardly valid, as steam can be superheated by the gas leaving the producer by passing the steam through one or two pipe coils hung in the downcomer. The steam takes up heat from the gas and becomes superheated without a material cooling of the gas proper. As the author shows, for a plant with 60 producers such an installation would cost only about $90.00 against which there is a saving of $1740.

The author comes to the conclusion that as ordinary steam blowers are not particularly suitable for gas producers to make a good gas in an economical way, the best solution of the problem is to blow the steam and air in separately. (*The Blast Furnace and Steel Plant*, p. 1039, December 1, 1915, 3 pp., 1 fig. *p*.)

Materials of Construction

Heat Treatment of Modern Steels, Robert R. Abbott.

The article discusses the heat treatment of modern steels, defining heat treatment in its broadest sense as the transformation of an alloy from a mechanical mixture of two substances into a homogeneous solution of a single substance. The article is illustrated by several micro-photographs showing the constituent parts of steel such as troostite, martensite, etc. (*The Iron Trade Review*, vol. 57, no. 21, p. 981, November 18, 1915, 6 pp., 21 figs. Cp. also The Journal, May 1915, p. 267. *g*).

The Cause and Effect of Ghost Lines in Large Steel Forgings, Prof. J. O. Arnold.

The paper gives an account of various investigations conducted during the past 20 years by the author, on the phenomena of ghosts in forgings of very large steel ingots ranging from 40 to 80 tons in weight. By ghosts or ghost lines are meant in this connection, parts of the ingot having

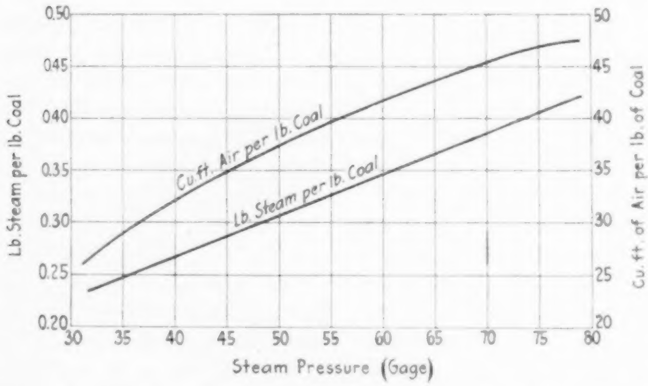

Fig. 3 Curves Showing the Connection between the Amounts of Air and Steam Blown into Gas Producers

a slightly different color from the rest of the metal. During the turning operations, these ghost lines usually show up quite plainly and in slight relief against the steel gray color of the mass, and by the means of a fine, sharp engraver's tool, they may be dug out and analyzed along with portions free from ghost lines. Analysis of the two give the following:

	Portions of forgings showing ghosts. Per cent	Portions of forgings ghost-free. Per cent
Carbon	0.380	0.320
Silicon	0.310	0.080
Manganese	0.920	0.680
Sulphur	0.045	0.020
Phosphorus	0.050	0.035

This shows an apparent segregation of all the five elements, although it is known now that the elements showing true segregation are carbon, sulphur and phosphorus, many large ghosts being almost free of silicates. From carefully carried out mechanical tests of stresses, tensile, torsional and alternating, the conclusion is drawn that ghost lines are little detrimental to the mechanical properties of structural steel so long as the plane of stress is at right angles to the direction of the ghost lines; in other words, when the material is in tension, torsion or under alternating stresses.

Comparatively recently, the author had the opportunity to ascertain the exact nature of unforged ghosts, some of which were ⅝ in. in diameter and 9 in. long, there being about fifty in the casting head. The casting of a mild steel chrome-nickel ingot, about 57 tons in weight, was just completed when a burst-out occurred at the bottom. This was stopped in about two minutes, but in that time the ingot was hollow for about 21 in. down, having "bled" about 17 tons of steel. On cutting off the hollow portion of the ingot and then cutting this longitudinally into four pieces, an extraordinary discovery was made, viz., in each octagonal angle was found a series of protruding frozen ghosts. With so much material available, it was easy to make an extensive chemical and microscopic examination, as some of the ghosts were protruding to an extent of ⅜ in. The surfaces of the steel free from ghosts showed decisive projecting ingots of octahedral crystals. The ghosts seem to have caught on the angle where the body of the ingot turns upward to the feeding head, seeming to have been mechanically trapped on what may be termed a series of metallurgical futtock shrouds.

While it has been the generally accepted dogma that ghosts, being higher in carbon, sulphur and phosphorus than the main mass of steel, necessarily freeze last, the present research shows that the ghosts freeze first at many degrees above the main mass freezing point.

The author and G. R. Bolsover have previously shown the existence of a definite solution or compound of iron and sulphide of manganese, which appeared to freeze before the main mass of the ingot, and on cooling, broke up into a mixture of iron and dots of sulphide of manganese. The composition of this mixture was tentatively suggested as 88 per cent iron and 12 per cent sulphide of manganese. Such a composition would be possessed of a relatively low specific gravity and would tend to rise through the still unfrozen main mass of steel. The author suggests that as this definite substance rises in a thick pasty or semi-frozen state, it forms in different parts of the ingot nuclei which gather to themselves the migratory particles of steel, viz., the carbon, phosphorus and in nickel steels, the nickelide of iron. (Paper read before the Institution of Mechanical Engineers, November 19, 1915, abstracted from preliminary publication, C).

Segregation and Sponginess in Ladle Test Ingots, Robert W. Hunt & Co.

In a recent case, where it was desired to have a check for the manufacturer's chemical analysis of each heat represented by a batch of open hearth steel rails, the result of the analyses of the inspectors differed so widely from those reported by the mills that it was finally deemed advisable to make some investigation of matters pertaining to ladle test ingots, and principally to the possibility of their segregation and soundness. From the outset, it has become clear that ladle test ingots were subject to unsoundness and segregation exactly as are all large ingots, the only difference being one of degree. Of particular importance is the fact that when the ladle test ingot is segregated and unsound, the drillings taken from it may not be representative of the steel or heat as a whole and the reported results will be misleading and untrue.

At the mill at which the tests were made, the ladle test ingot mold was about 2½ in. square at the top, 2 in. square at the bottom and 5 in. high. When the ingots were drilled, many cavities were encountered. The analysis of the drillings taken from the various parts of the ingot showed that the outside portions of the ingots differed from those near the inside, and different locations of the drillings with respect to the height practically always gave different results. The degree of porosity is apparently somewhat greater in the

ingot from the first part of the heat than that from the last and further addition of the dioxidizing agent, ferro-silica, experimented with in one case, made that ingot absolutely sound for the greater part of its height. In this connection, the article shows an interesting collection of diagrams of various ladle test ingots adopted by prominent rail manufacturers in this country.

Soundness or freedom from blowholes, etc., is a very important feature for ladle test ingots to possess, as the more unsound one is, the more it is inclined to be segregated and also in drilling steel that is full of blowholes, minute particles break off from the sides of the holes and render a chemical determination for carbon by combustion methods more difficult of accuracy than one for which flake-like drillings are furnished. The authors arrive at the following general conclusion: That while the soundness of the test ingot is not predicted by its shape, this slab-like shape is preferable because of its tendency to chill quickly and thus solidify with the minimum amount of segregation; the disadvantage of this shape of test ingot lays principally in the difficulty of obtaining sufficient drillings for the requisite number of analyses.

The writers recommend, therefore, as additions to rail specifications, the following: *First,* a standard shape and size for ladle test ingots with directions as to the size of drilling and location of the borings on which the analysis is made; *second,* the addition of aluminum, preferably in the dipper, when necessary, to insure a sound setting steel in the ladle test ingots with freedom from blowholes. (*Bulletin of the American Railway Engineering Association,* vol. 17, no. 179, p. 27, September 1915, 8 pp., 9 figs. *e.*)

INFLUENCE OF TEMPERATURE AND MECHANICAL WORKING IN HYDRAULIC FORGING ON THE PHYSICAL PROPERTIES OF WROUGHT IRON AND STEEL, Dr. Otto Fuchs

The tests referred to in this article were made by Committee V of the Austrian Association for the Testing of Engineering Materials, and had for their purpose to establish what influence temperature and mechanical work in forging, drawing and rolling of wrought iron and steel had on the mechanical properties of the latter. The article describes in a general manner the method of testing adopted in this connection and gives data obtained in the form of curves.

In the first place, it was desired to investigate how the force applied and the work necessary to change the shape of the material vary with the temperature at which it is forged. From previous experience, it was expected that with increase of temperature, the force and work required would gradually decrease, but the curves obtained showed that such lowering of the curve of power consumption begins only at about 850 deg. cent. (1562 deg. fahr.), but previous to that it increases with the increase of temperature of forging. The author ascribes this phenomenon to allotropic transformations in the iron.

In order to obtain an insight into the relation between the pressure temperature curves (Fig. 1) and the points of transformation Ar_2 and Ar_3, the latter have been determined by the differential process of Roberts-Austen, and it was found that each rise of the line is located within the region of transformation of the iron. Through the segregation of the crystals of the β iron from the solid solution (that is at point Ar_3) the alloy becomes softer, which lasts until the β iron is transformed into α iron. In the case of iron-carbon alloys, where Ar_2 and Ar_3 coincide and in general in alloys containing more than 0.5 per cent of carbon, there is observable a certain unsteadiness in the consumption of power. It must be observed, however, that with the apparatus available, it was generally difficult to obtain a reliable work (or pressure)-temperature curve, since it was hardly possible to carry out the jumping of the metal at the instant of transformation. Therefore the curves *c* and *d*, corresponding to a material in which, notwithstanding the presence of only 0.2 per cent of carbon, the formation of the β iron in the cooling test could not be clearly established, showed a considerable uncertainty in shape. Hence no attempt was made for the region of critical temperatures to connect the experimental values denoted by a smooth curve. It appears to be likely that, as with the increase in carbon content the points Ar_2 and Ar_3 approach each other, the temperature periods within which the above described softening occurs will also become smaller, with the result that within that region the consumption of power will undergo a sudden alteration.

Since in the material treated in the tests we have a case of constrained state, it appeared in the light of previous experience with constituents either unstable or metastable at room

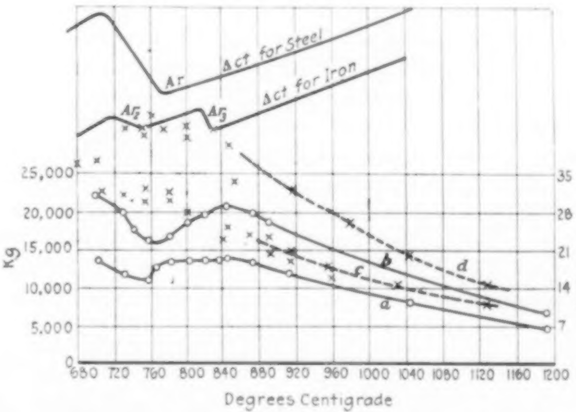

FIG. 4 PRESSURE-TEMPERATURE CURVES FOR WROUGHT IRON AND STEEL

a, jumping of iron, 10 per cent; *b*, same, 20 per cent; *c*, same for steel, 10 per cent; *d*, same for steel, 20 per cent. *ct*, lines for the critical points. Abscissae, temperatures; ordinates, differences of thermo-electric forces.

temperature (martensite, osmondite, troostite and sorbite), to be important to determine whether the usual constitution of the metal would appear through heating to a temperature beyond the critical range. It appeared that this did not happen in the case of a short heating to a temperature of 1000 deg. cent. (1832 deg. fahr.), but after a two hours' heating, up to 1200 deg. cent. (2192 deg. fahr.), and then a slow cooling, the grained structure reappeared with perfect clearness, the grains of ferrite being considerably larger than before.

The influence of the temperature of forging on the grain structure, which was observed with soft and hard material, led to the expectation that there would also be observed a difference in the physical and mechanical properties. Hence the materials were also tested for hardness and it was found that material upset within a critical range of temperatures was softer than that worked at temperatures either above or below the critical range. This might have been expected since within that range the material is more plastic and therefore a special softness was likely to appear in worked material, even after cooling.

The dependence of the structure of the material on the temperature of forging might be explained in the following manner: The test pieces were heated in a similar manner up to the maximum temperature obtainable in the muffle oven, which is somewhere around 1200 deg. cent. (2192 deg. fahr). The

size of grain, which tends to grow in all specimens, must, according to Heyn, be the same for all of them at the time when they are taken from the furnace; then all the test pieces were also cooled in a similar manner with that single essential difference that at various temperatures during the period of cooling they underwent a certain amount of mechanical work. The structure which can be seen in the iron under a microscope is that due to the transformations which occur in the region of temperatures between 900 and 780 deg. cent. (1652 and 1436 deg. fahr.) and is not at all the structure of solidification since the latter is covered over by the new grain formation produced by recrystallization. The small grain structure is, therefore, determined by the fact of how far the recrystallization has been allowed to occur without outside interference. Provided the process of transformation occurred without outside interference the size of the grains will depend on the velocity with which this range of temperature has been gone through, the lower the velocity the larger the size of the crystals. The segregation or crystallization is possible only if the smallest parts of the alloy affected by the transformation have a sufficient mobility, and if the mobility in the region of temperatures between 900 and 780 deg. cent. was interfered with by the high pressure applied to the test piece the formation of the grains will be likewise more or less interfered with, and it is well worth attention that the structure formed when the grain growth was interfered with is noticeably lower in hardness. (*Der Einfluss von Temperatur und mechanischer Arbeit beim Pressschmieden von Flusseisen und Stahl,* Dr. tech. Otto Fuchs, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, No. 45, p. 915, November 6, 1915, 4 pp., 3 figs. *e.*)

A DEVELOPMENT OF A HIGH GRADE ALLOY STEEL AT LOW COST, Lieutenant J. B. Rhodes, U.S.N.

Description of the manufacture and qualities of an alloy steel which has been found to furnish high grade castings and forgings at a comparatively low cost. No originality is claimed for this alloy but the writer believes that it has been regularly manufactured for use for the first time. It is also of interest because its production is largely based on the utilization of metal scraps which would otherwise be sold at a low price.

The problem was to find a steel which could be used for forgings when the latter are required to show the following minimum physical values in a transverse direction.

Torsional strength, 95,000 lb. per sq. in.
Proportional limit, 65,000 lb. per sq. in.
Elongation, 18 per cent.
Reduction of area 30 per cent.

The development of the present steel was based on the following considerations: First, it was believed that in order to obtain a steel of high physical properties with considerable ductility and good machining qualities, it is necessary to produce a pearlitic steel. Hence it was decided to limit the percentages of each hardening or toughening element and to increase the pearlite by the use of additional elements; namely, by adding copper and manganese to the usual nickel-steel alloy. It was further decided to limit the carbon to 0.35 per cent and manganese to 1.20 per cent or about 0.60 per cent higher than normal. It was found that nickel could be obtained in turnings from 3 per cent nickel-steel in sufficient quantity to give 1 per cent to 1.5 per cent in the steel, and nickel with copper could be obtained in the form of monel-metal scrap in turnings containing approximately 65 per cent nickel and 30 per cent copper.

The increase in manganese by 0.6 per cent or 6 lb. per 1,000 can be made by adding not more than 10 lb. per 1,000 of material, which in the form of 80 per cent ferro-manganese, costs about \$0.06 per lb. for manganese, an increase of 60 cents per 1,000 lb. or \$0.006 per lb. Nickel-steel turnings are worth about \$10.00 a ton more than ordinary scrap (as based on sale of own scrap), which means that nickel in this form is obtained for \$0.05 per lb. instead of \$0.35 or \$0.40 per lb. To obtain 1.0 per cent to 1.5 per cent nickel, 15 lb. per ton are added, at a cost of 75 cents per 1,000 lb., or \$0.00075 per lb. To obtain 0.50-0.75 per cent copper, monel-metal scrap at \$0.12 per lb. is added. Two per cent of monel-metal gives 0.70 per cent copper and 1.20 per cent nickel, at a cost of \$2.40 per 1,000 lb., or \$0.0024 per lb. The cost of these additions are as follows:

Manganese	\$0.0006
Nickel	0.00075
Monel	0.0024
Total	\$0.00375

So that for an increase of less than \$0.004 per lb. we obtain a steel equal in properties to a 3 per cent nickel-steel. The composition of the steel may be taken to be as follows:

Carbon	0.30 per cent to 0.35 per cent
Silicon	0.25 per cent to 0.35 per cent
Phosphorus and sulphur.	not over 0.05 per cent
Manganese	1.00 to 1.20 per cent
Nickel	1.50 to 1.80 per cent
Copper	0.50 per cent to 0.80 per cent

which steel will show properties equal to those specified.

It is believed that the excess manganese prevents red shortness due to copper oxide by combining with any oxygen present in the bath. Castings are remarkably free from checks, cracks, blowholes and shrinks, and ingots are normal. (*Journal of the American Society of Naval Engineers,* vol. 27, no. 4, p. 911, November 1915, 5 pp., *dp*).

THE EFFECT OF CARBON ON THE PHYSICAL PROPERTIES OF HEAT-TREATED CARBON STEEL, J. H. Nead

Description of experiments undertaken with a view to investigating thoroughly the influence of carbon on the tensile and impact physical properties of carbon steel.

In the steels investigated the carbon content varied gradually from 0.14 to .46 per cent and the manganese content from 0.20 to 0.67 per cent. (It was thought that the variations in manganese content were not sufficiently great to disturb seriously the conclusions to be drawn as to the effect of the carbon).

The paper describes in detail the layout of heat treatment, and gives annealing and hardening temperatures used for each steel, the results of the tests being summarized in the form of tables and curves. Under the annealed condition, the maximum unit of strength reaches a maximum value at eutectoid composition, that is, 0.80 per cent carbon, and then decreases slightly with increasing carbon. With the heat treated steel, however, the falling off of the maximum strength does not begin until a composition of .20 per cent carbon is reached. The curves obtained show a rapid rise of tensile strength with increasing carbon to eutectoid composition; then a less rapid increase to 1.20 per cent carbon, followed generally by a slight falling off. The curves representing elongation and contraction generally show decreasing values with increasing carbon. (*Bulletin of the American Institute of Mining Engineers,* No. 108, p. 2341, December, 1915, 18 pp., 29 figs. *eA.*)

Carbides of Molybdenum, J. O. Arnold.

Paper on the chemical and mechanical relations of iron, molybdenum and carbon, representing an investigation of the method of manufacture, heat treatment and mechanical properties of molybdenum steels. It appears that at about 18.25 per cent molybdenum, free carbide of iron disappears and double carbide of iron and molybdenum is obtained, corresponding to the formula, $Fe_2 Mo_3 C$. (Constitutionally, the formula is $Fe_6 Mo_6 C_2$).

The conclusion from the paper is that one atom of carbon is about 2.28 times as powerful in producing hardenite in true ferro-molybdenum steel as it is in forming the hardenite in true tungsten steel, which roughly agrees with the estimation of practical Sheffield steel metallurgists to the effect that the steel hardening power of molybdenum is from two to three times as great as that of tungsten. Unfortunately, however, molybdenum is much more erratic in its behavior than tungsten, and the author calls attention to the very poor mechanical properties of molybdenum steels as compared with corresponding steels containing tungsten. High molybdenum steel, quenched at the proper hardening temperature, is very brittle and only a low percentage of molybdenum should be used, either alone or to replace about two and a half times its percentage of tungsten. Tungsten completely replaces carbide of iron when about 11.28 per cent is present; molybdenum when about 18.25 per cent, but molybdenum combines with a large proportion of the carbide of iron forming a very stable double carbide. Very high molybdenum seems to cause ferro-cementite to segregate more readily in annealed steel. Ferro-molybdenum hardenite also resembles that of vanadium in brittleness when quenched above its complete transformation temperature. (From abstract in the *Journal of the Institution of Mechanical Engineers* (London), No. 8, 1915. Complete paper not yet published).

Experience with Protected Timber Piles in Tropical Waters, at San Juan, Porto Rico, J. P. Carlin

The paper discusses the use of so-called "gunite" coated piles in tropical waters.

The gunite coating consists of wrapping an ordinary wooden pile for a distance to be exposed to the water, with wire mesh secured by staples. Upon this mesh reinforcement is placed a coating of cement mortar applied under air pressure and by means of a cement gun. In the experiments made by Lilley and Thurston, of San Francisco, the thickness of this coating, including the reinforcements, was about 1 in. to 1⅛ in., and it appeared that satisfactory results were obtained. The same type was used in the construction of the San Juan bulkhead in Porto Rico, but in that, two thicknesses of metal fabric were spirally wound about eight-¼ in. rods, held by a staple and running the length of the coated pile. The thickness of the gunite material was increased from 2½ to 3 in. A number of these coated piles were prepared, kept wet for several days and allowed to set for at least 30 days before driving. The condition of the ground was such that very severe driving was necessary and many of the piles were damaged, which finally made the method prohibitive and forced recourse to solid concrete piles. Among other things, the article describes a method of repairing damaged cement coated piles under water. The author believes that if some method can be devised of rotating the pile without sagging during the application of the gunite and also of handling the piles from the rollers to the seasoning yard, this method can be satisfactorily and economically employed. (*The Cornell Civil Engineer*, vol. 24, no. 2, p. 50, November 1915, 5 pp., 2 figs. *dp*).

Measuring Apparatus

Plate Fulcrum Track Scale, A. W. Epright

Description of a track scale of a new type installed in the gravity yard at East Tyrone, Pa., by the Pennsylvania Railroad, in several respects a radical departure from the usual design of track scales. In the present case, no pivots, knife edges, bearing steels, loops or links, are employed in connection with the vibratory system to transmit the load from the platform to the indicating poise beam. Instead, a "plate fulcrum" has been substituted and a series of tests under both concentrated and distributed loads are claimed to have demonstrated that the plate fulcrum construction possesses certain advantages over the "knife edge and pivot" construction, the principal among which is the fact that the sensibility does not materially change under varying increments of load but is almost the same under maximum load as with an empty balance. There is no motion whatever, either transverse or longitudinal, to the bridge or fulcrum supporting the weighing rail, and as a result the action of the lever system is not affected by change in repose of the weighing platform as the latter does not oscillate under moving loads.

The checking of the bridge is accomplished through massive stay-plates instead of check-rods. A wide departure from the previous construction lies in the fact that no parts of the scale are permanently bolted to the scale bridge proper, the bridge being supported by rollers which rest on hardened plates, the rollers being placed intermediate between the bridge and the lever system, so that the load is centrally distributed on the plate fulcrums in the main levers.

The scale installed at East Tyrone is 54 ft. long being built on a 0.8 per cent grade and equipped with mechanical hump. It still remains to be seen what will be the effect on the action of the scale of continued hard usage, but its operations to date are claimed to have been entirely satisfactory. A feature worth noticing is the elimination of many levers and fulcrums. In this case, there are four sections in the scale, the primary system or main levers being arranged transverse to the direction of the traffic, while the secondary system is arranged longitudinally. There are no compound levers which perform the function similarly to what is known as the middle extension lever, which greatly simplifies the adjustment when calibrating the scale leverage. (*Scale Journal*, vol. 2, no. 2, p. 5, November 25, 1915, 3 pp., 8 figs. *d*.)

Apparatus for Measuring the Velocity and Pressure of Gases, E. Stach

Apparatus for measuring the velocity of gases. Continuation of the article abstracted in *The Journal* for December, 1915, p. 715.

Among the apparatus described here are of particular interest those intended for measuring very low velocities, say under 0.5 m per second, for which purpose wing anemometers are not dependable, as their internal friction is too high. For such purposes R. Fuess has developed the highly sensitive anemometer shown in Fig. 5A, in which the wing is set into motion by a little fan driven by a spring at a velocity which may be adjusted by means of the screw *r*. The screw *s* applies the brake to the driving spring when the measurement has been ended.

If, now, this fan be located in an air current, the direction of which is opposed to the flow of air from the fan driving the anemometer wing and the velocity of which is lower than that of the stream coming from the fan, the motion of the wing will be retarded, and on the scale *z* a lower value will appear than that in stationary air. The difference between

the two readings indicates the velocity to be determined. By means of this anemometer, velocities as low as 0.03 m per second can be read.

For continuous measurements in pipes carrying high pressures, or at the end of such pipes, e.g., in compressed air piping, Rosenmüller builds an automatic anemometer (Fig. B) in which the entire gas stream must pass through the anemometer wing. These anemometers are built with wing diameters up to 145 mm, and when built into the piping, join the pipe by means of smooth-walled nozzles, whenever the diameter of the piping and wing do not coincide. Attention is here called to the middle section of the apparatus, which adapts itself to the direction of the stream lines, protects the arms of the wing device and automatically leads the entire flow of gas through the area of the wings. The scale, which can be seen through the glass cover, is divided into cubic meters. To this anemometer can also be adapted a chronograph for distant readings.

Wing anemometers, because of their delicate construction, are only good for velocities up to about 10 mm per second, since at the higher velocities there begins to occur excessive bending of the wings and excessive axial pressures. Therefore, for higher velocities, such as in compressed air piping, ventilation passages of mines and meteorology, cup anemometers, such as that of Robinson, (Fig. C) are considered preferable.

Figs. D and E show two devices of cup anemometers, the first built by Rosenmüller and the second by Stach-Fuess, respectively, with electric attachments for distant reading. The anemometer shown in Fig. E in particular is provided with caps over the axial bearings and electric contacts, making it both dust and water tight, which is of advantage for use in dusty places and for meteorological purposes. The chronograph used in connection with the Stach-Fuess anemometer is shown in Fig. F.

The recording is done in the following manner. After 200, 500 and 1000 revolutions of the cup device, (in accordance with the sensitiveness of the anemometer) a mark is drawn on the paper roll of the chronograph by a stylus attracted through an electric contact of the magnet screw. This magnet, with its stylus, is deflected upward by the spindle *s*, rotating at the same speed as the drum *u*, so that the stylus marks on the paper spirals which are interrupted by the vertical contact records. As the drum *u* makes one full revolution per hour, the distance between the contact and vertical marks is therefore a function of the measuring gas velocity, the magnitude of which is determined experimentally and expressed in a proper equation.

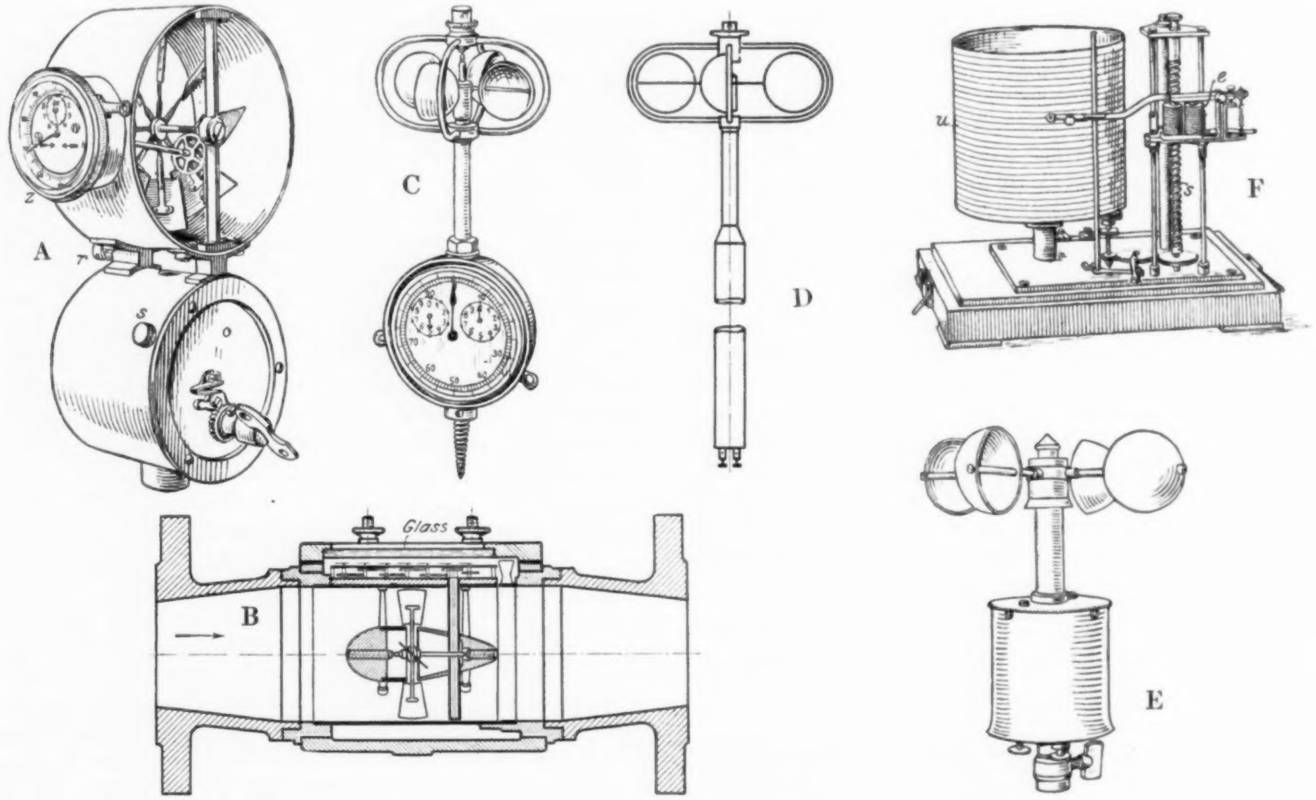

FIG. 5 APPARATUS FOR MEASURING THE VELOCITY AND PRESSURE OF GASES; A SCHULTZ-FUESS ANEMOMETER FOR LOW AIR VELOCITIES; B ROSENMULLER BUILT-IN ANEMOMETER FOR MEASURING AIR VELOCITIES IN COMPRESSED AIR PIPING; C ROBINSON CUP ANEMOMETER; D ROSENMULLER CUP ANEMOMETER; E STACH-FUESS CUP ANEMOMETER; F CHRONOGRAPH

The article proceeds to describe methods of testing anemometers and among other things describes and illustrates the special apparatus for callibration of anemometers used at the Bochum School of Mines. (*Messgeräte für Druck und Geschwindigkeit von Gasen*, E. Stach, *Zeits. des Vereines deutcher Ingenieure*, vol. 59, no. 43, p. 878, October 23, 1915, article not finished).

Mechanics

CONCERNING MEASUREMENTS OF THE COEFFICIENT OF CYCLIC VARIATION, Prof. J. von Rohonyi

The article discusses methods of measuring the coefficient of degree of uniformity in the motion of prime movers.

The first impetus toward precise determination of the de-

gree of uniformity in the motion of prime movers was given by Radinger, in his work "Steam Engine With High Piston Velocity" (Third edition 1892, p. 338, in German). Since then, a number of other investigations have been published and the author of the present article, among others, has carried out a series of independent tests on the subject in 1911 for which he describes the experimental arrangement.

A disc a (Fig. 6A) with a large moment of inertia, is connected to another disc b by an elastic coupling c, which in its turn rigidly is connected with the axis of the engine. In the case of radial motion with varying velocities, the relative positions of the two discs change with respect to one another and in particular when the axis of the engine, together with the disc b are under an acceleration, the disc a, because of its inertia tends to lag, while in the case of the retardation of the disc b, the disc a tends to lead it.

The relative displacement of discs a and b denoted here as "pendular motions" can be recorded by means of a lever arrangement or spring device (Fig. B) or by means of a mirror in such a way that they would give a diagram from which the oscillations in velocity could be seen. If it be assumed that the forces acting on the crank of the engine vary in accordance with a sine function (Fig. C), the velocity diagram will give a similar curve, lagging by $\pi/2$, which means a cosine curve. The tangential forces can here be denoted as "pendular" forces, as they give the greatest relative displacement of the two discs (or "pendular" motions of the discs), provided one considers as an axis of abscissae not the o — o line, but the axis of symmetry of the curve.

The paths which are travelled over because of the displacements of the discs a and b, due to their relative rotations or pendular motions, may be plotted as ordinates of a sine curve, but with a displacement equal to $\pi/2$. The points of inflection of the pendular curves are called by the author "meeting points" (denoted by $B.\ P$), since the points on the discs a and b which are equivalent while the discs are at rest, meet at these points during the pendular motions of the discs and in the moments of time corresponding to these points there is neither lead nor lag in their relative motions. This permits the determining of the coefficient of cyclic variation with a precision sufficient for practical purposes, by drawing through the point of inflection a tangent line, whereupon the angle formed by the line with the horizontal (Fig. C) or $\operatorname{tg} \alpha = v \ \Delta$ represents nothing but the positive and negative variations in velocities with respect to the average velocity. Since, however, it follows from the velocity diagram that

$$v_{max} - v_{min} = 2v$$

hence the coefficient of cyclic variation in the motion of a prime mover is $\delta \dfrac{v_{max} - v_{min}}{v} = \dfrac{2v\Delta}{v} = \dfrac{2\operatorname{tg}\alpha}{v}$

The average velocity v may be precisely determined by means of a tachometer or speed counter.

The diagram of pendular motions is, however, affected by a source of errors. The motion of the disc b undergoes a damping because of friction and air resistance, and since, through its drive, by an elastic coupling, is not uniform in itself, the disc will rotate with a similar degree of cyclic variation. This error is, however, apparent only in the peaks of the diagram of pendular motions, and since, for practical purposes, this part of the curve need not be considered, the error is of no importance. The author further considers it advisable to make the records in such a manner that the displacements should be magnified to such a degree that the peaks of the curves are beyond the field of vision. As an example of his method, he gives two diagrams which are not reproduced here. He also describes an apparatus designed by him for the measurement of the degree of uniformity in accordance with the above established general principles. (*Über das Messen des Ungleichformigkeitsgrades*, Prof. Ing. Julius von Rohonyi, *Dinglers polytechnisches Journal*, vol. 330, no. 23, p. 441, November 13, 1915, 3 pp., 5 figs. *ed*).

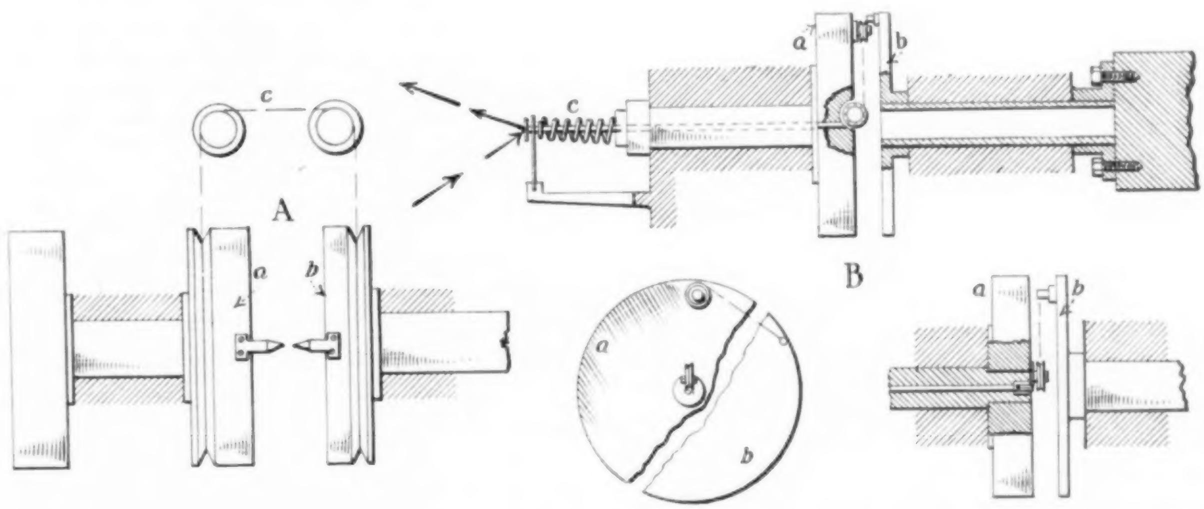

FIG. 6 A, B EXPERIMENTAL ARRANGEMENT FOR MEASURING THE COEFFICIENT OF CYCLIC VARIATION IN THE MOTION OF PRIME MOVERS

POWER REQUIREMENTS FOR WIRE DRAWING, Kenneth B. Lewis

The paper presents a critical consideration of the factors to be met in the manufacture of wire and in drawing rods.

The calculation of the power required in wire drawing operations is constantly becoming a problem that calls for more accurate solution. Wire mills working on a general line of production drawn from the No. 5 rod do not feel the need of such a solution, but a master mechanic of wire drawing equipment must be also prepared to figure the power for a single unit under a very definite set of operating conditions. With motor drive, it is advisable to know not only the average, but also the power demanded under the most adverse conditions, in other words, the peak load. This is particularly true of

rod benches with blocks engaged in heavy work. Then sometimes definite assurances must be given to users of cold drawn products that the motor furnished will carry their peak load. Finally, motor driven heavy bull frames with one or two blocks are replacing the straight draw benches for products between 1 in. and ½ in. in diameter; they handle much longer lengths than the straight benches, and as they generally carry two independently operated blocks their cycle is very different, and the motors must be in reserve for peak load if both blocks happen to start simultaneously.

The writer has checked up the existing rule of thumb method for figuring wire drawing power with about 60 actual motor readings made under known conditions and covering a

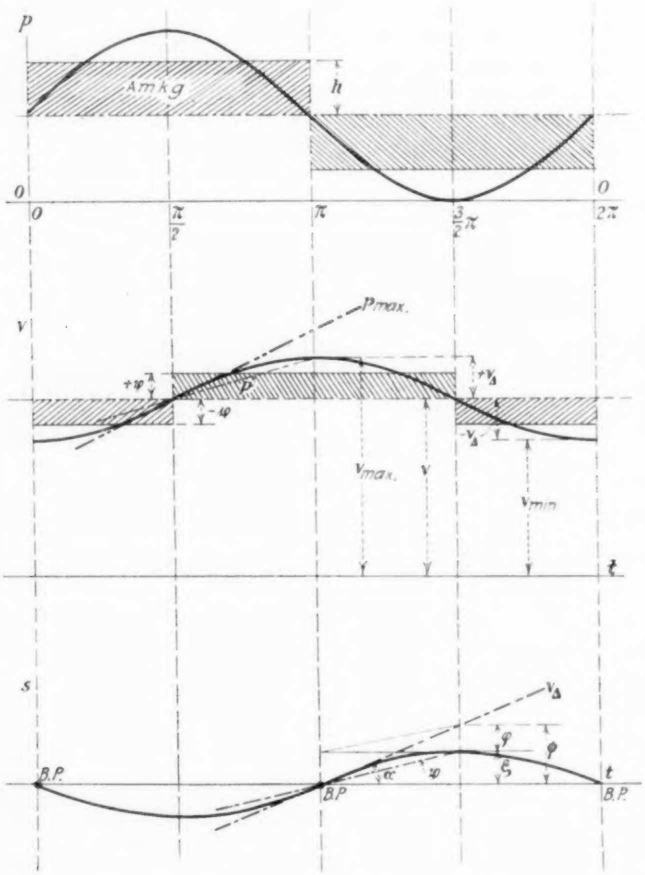

Fig. 6C Diagrams of Pendular Motions

very wide range as to size and material. The power called for by the formula averages about one-half that shown by the motor readings. The most serious difficulty with the formula is that in its present form, even when its value is doubled, many observed motor readings vary from it by as much as 60 per cent or 70 per cent, over and under. The reason seems to be that the figure representing the material displaced is the only factor in the equation which carries a suggestion as to the size of wire. The author proposes, therefore, an amended formula as follows:

$$\text{HP} = TS \times (A - a) \times S \times F/33000$$

where

TS = tensile strength per sq. in. of stock before the draft
S = speed in feet per minute
A = area of wire before drawing
a = area of wire after drawing
F = factor chosen from a chart which is given in the article

This formula which the writer has found fairly satisfactory does not take into account certain factors which cannot be determined in practical working, such as shape of the bearing in the die, efficiency of lubricant, amount of friction in the machine, etc.

The formula as developed is not what might be called a logical equation as its derivation is not strictly consistent. There is another formula which not only gives as satisfactory results in practical work as the above, but also gives consistent values at both ends of the scale of reduction. It is the formula of Victor E. Edwards for rolling mill operations as follows:

$$\text{HP} = TS \times T \times \log \frac{A}{a} \times F$$

where TS = tensile strength in lb. per sq. in. of stock before the draft
T = tons per minute delivered
A = area of section before the draft
a = area of section after the draft
F = variable factor

The author has analyzed results obtained by this formula in connection with motor readings and finds that the value F varies inversely with the percentage of reduction, its variation in the usual range of draft being from 0.12 to 0.08, and is apparently perfectly regular. This formula may be also applied without change to continuous wire drawing operations in which many reductions are performed simultaneously upon the same wire. In such cases T is figured for the product of one die only while the values for TS and F are averages. All these formulae are good for round wires only. Hexagons and squares conform to these figures more or less, but other shapes do not. (*The Blast Furnace and Steel Plant*, December 1915, p. 1031, 4 pp., 3 figs. *pe*).

The Horseless Age Engineering Charts

The article refers to a series of handy computing charts, the purpose of which is to provide short-cuts in the making of calculations. One of the charts is for computing the valve springs for mushroom cams by means of which it is possible to determine exactly the spring pressure required for a motor of any maximum speed using muchroom cam followers having reciprocating parts of any weight and employing any size of cam. Other charts give the capacity of cone clutches, capacity of dry disc clutches, critical speed of solid and hollow shafts and brake mean effective pressures. (*Horseless Age*, vol. 36, no. 13, p. 497, December 1, 1915, 2 pp., 2 figs. *p*.)

Design of Crankshafts for High-Speed Engines, P. M. Heldt

The paper discusses the design of crank shafts for high speed engines and gives equations for the proportions of some of the various types of crank shafts for engines of different numbers of cylinders.

The author calls attention to the fact that crank shafts have become more substantial and more rigid from year to year largely on account of the demand for high engine speed combined with quiet vibrationless operation. The crank shaft must be made rigid in order to obviate excessive torsional vibration at so-called critical speeds. Formerly, the crank pin diameter was made directly proportional to the cylinder bore and independent of the stroke, but in recent years piston speeds have been so greatly increased that it is the inertia of the reciprocating parts rather than the explosion pressure that is now the chief factor in determining the load on the piston pin. At high engine speeds there is

very little pressure on the crank pin during the first part of the explosion stroke, as the force of the explosion is nearly balanced by the opposite stroke force of inertia on the piston on the upper end of the connecting rod. Initial forces, due to reciprocating parts, are acting during all four strokes, and therefore it may safely be said that at high speeds the greater part of the bearing load on the crank pin is due to initial forces.

The author gives empirical rules for dimensioning crank shafts in automobile motors, based on carefully selected data of recent motors. These cover three bearing 4-cylinder crank shafts, three bearing 6-cylinder crank shafts and four bearing 6-cylinder crank shafts.

The article is to be continued. (*Horseless Age*, vol. 36, no. 13, p. 498. December 1, 1915. *pt.*)

THE MYSTERY OF THE SCREW PROPELLER, C. W. Dyson.

The paper discusses in a mathematical manner the seeming vagaries of performances of screw propellers on ships in actual service. Some of these vagaries are attributed to the effect of variations in hull form as interfering with the proper flow of water to the propeller or producing more or less wake and so adding to the propulsive efficiency, or the vagaries in propeller efficiency may be due to incorrect estimates of effective horsepower required for a given speed because of neglecting the resistance due to appendages such as struts, bilge keels, etc. The remaining portion of the mystery may be due to variations in blade form and sections of the propeller itself, and to incomplete understanding of propeller performances proper.

The author comes to the conclusion that the efficiency of performance of a propeller is seriously affected by its position in relation to the hull of the vessel which it is driving, and by the fullness of the hull lines at the afterbody. For any given propeller working under constant hull conditions of form, the effective horsepower for any given engine power remains constant and thus is independent of the speed of the vessel. For any given propeller working under constant hull conditions of form the revolutions necessary to deliver any given effective horsepower vary with the speed of ship, the engine power remaining constant. Model tank effective horsepower curves are correct, but results obtained from model tank experiments with model propellers are correct only when the model is properly proportioned to the full size propeller which does not mean that the pitch ratio of the propeller and of the model shall be the same. (*Journal of the American Society of Naval Engineers*, vol. 27, no. 4, p. 743. November 1915, 50 pp., 5 figs., *dm.*)

Refrigeration

FLOW OF SUPERHEATED AMMONIA THROUGH ORIFICES, Edward F. Miller

At the instigation of the Massachusetts State Board of Boiler Rules, F. L. Fairbanks, L. Williams and E. F. Miller, as members of a committee appointed by the American Society of Refrigerating Engineers, together with Prof. C. A. Read, of Worcester Polytechnic Institute, and G. H. Clark, of the Massachusetts Institute of Technology, have carried out a series of tests at the plant of the Quincy Market Storage and Warehouse Company, on the flow of superheated ammonia through orifices and several other cognate matters.

Among other things, orifices of different diameters, of different lengths and with different radii of entrance curves were tested. The diameter of the discharge outlet and of a discharge pipe 100 ft. in length which would be required to take care of the amounts of gas discharged with 5 lb. accumulation pressure at the entrance end, and atmospheric at the exit end, was figured by the Babcock formula. It was found that it would have been impossible to use discharge pipes of the large diameters called for and the committee decided to arrange a safety valve to discharge into a pipe where the pressure might accumulate at time of maximum discharge, to 0.585 the entrance pressure, or with 275 lb. gage entrance pressure to 154 lb. gage. In such a valve the back pressure must be kept from acting on the back of the valve. Such a valve has been made by Mr. Fairbanks. (Description of this valve will be found on page 97.) The same idea has been embodied in a new steam safety valve which, on test, was found to work perfectly.

The Committee found no data available from which to calculate the diameter of a pipe of a given length which is to discharge the given weight of gas per minute entering at 154 lb. gage and leaving at atmospheric pressure. Therefore a run of pipe was erected and some data obtained. Further, a straight run of 2 in. pipe, 260 ft. long, was also installed and a known weight of saturated steam at high pressure sent into one end of the pipe, the other end being open. From the data thus obtained, the committee felt warranted in fixing the sizes of the discharge pipes as shown in Table 1. For the second 100 ft., the pipe should increase one pipe size and so on for each additional 100 ft. Pipe bent to a radius at least as great as five pipe diameters has to be used when it is necessary to turn a corner.

A number of tests were made on flow of superheated ammonia gas through an orifice, of which data are reported in three tables in the original article. It appears from these tests that the radius of the curve at entrance should be at least one-half the diameter of the orifice and that the straight part of the orifice should be $1\frac{1}{2}$ diameters long. In such orifices, the absolute pressure in the orifices may be assumed to be 0.585 of the absolute head pressure and the throat back pressure is not greater than 0.585 times the head pressure. If the back pressure is greater than 0.585 the head pressure, then the pressure in the orifice may be assumed to be a slight amount, perhaps 1 lb., above the back pressure. If an adiabatic expansion be assumed from head pressure and conditions to throat pressure, then the weight going through the orifice per second may be calculated from the following formula:

$$V = 224\sqrt{H_e - H_o};\frac{V \times a}{z} = \text{weight}$$

where V = velocity in feet per second; a = area of orifices in

TABLE 1 SIZES OF DISCHARGE PIPES

Piston Displacement Cubic Feet Per Min.	Diameter of Valve	Diameter of Discharge Pipe for First 100 Feet
120	½ inch	1
280	¾ "	1¼
510	1 "	1½
830	1¼ "	2
1200	1½ "	2½
2120	2 "	3

square inches divided by 144 or the area of the orifices in square feet; z = volume of 1 lb. of ammonia gas at the throat pressure and condition in the orifice; H_e = heat content of 1 lb. of ammonia at head pressure and condition; H_o = heat content of 1 lb. of ammonia at throat pressure condition.

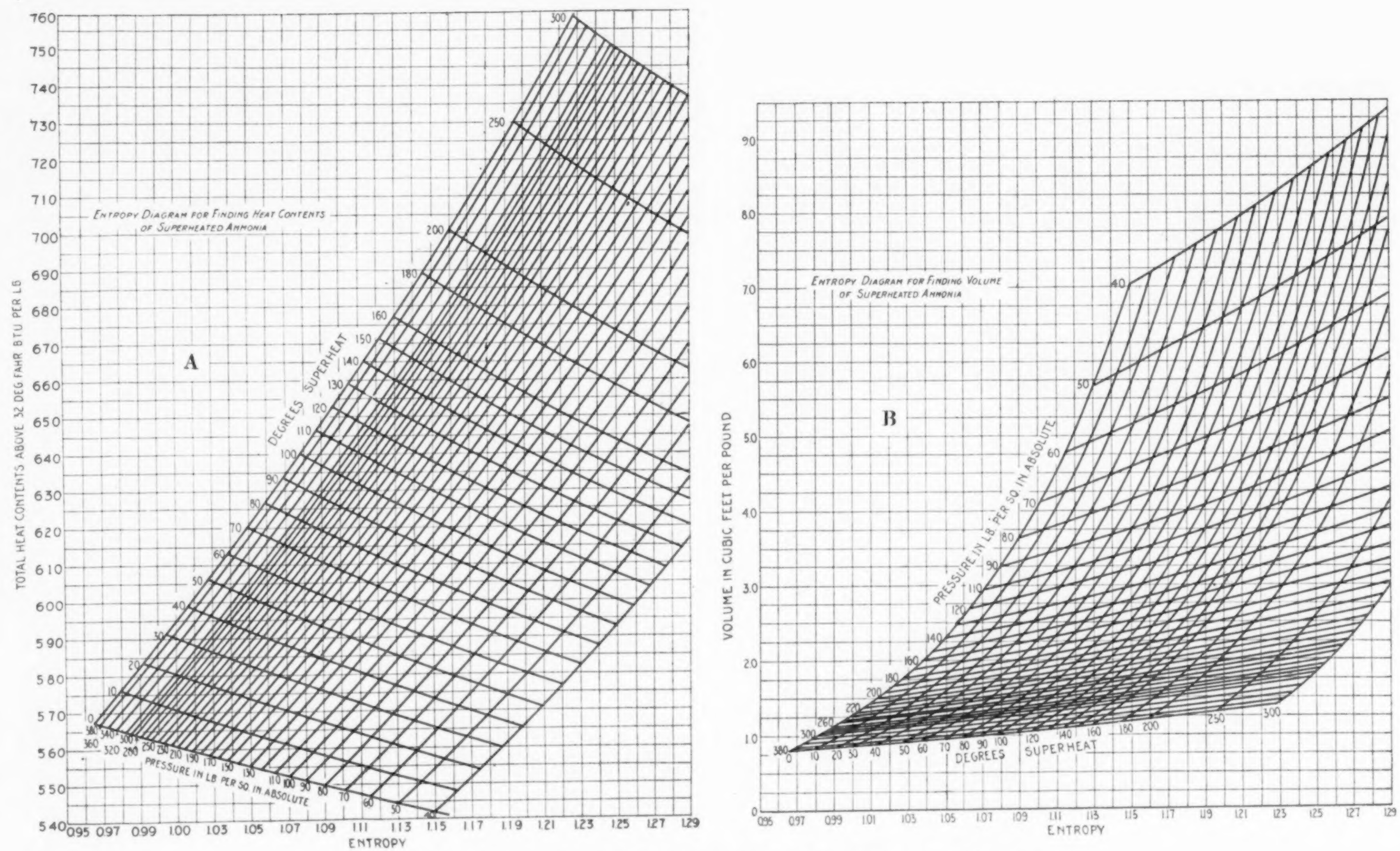

FIG. 7 A, HEAT CONTENT PLOT; B, VOLUME PLOT FOR SUPERHEATED AMMONIA

DIRECTIONS FOR USE OF THE PLOTS

Knowing the head pressure and the degree of superheat, the *Heat Contents* H_e can be read off from Fig. A. The entropy is noted. Following down at constant entropy to the pressure in the orifice, the Heat Contents H_0 can be read; also the number of degrees the gas in the orifice is superheated.

On the plot Fig. B, follow up on the same entropy to the pressure in the orifice and Z, the volume of a pound at the condition in the orifice, can be read.

To save interpolation in the Goodenough and Mosher's tables, the authors offer two plots from which, knowing the head pressure and the degrees of superheat, the volume of a pound at the condition in the orifice can be read. (A.S.R.E. Journal, vol. 2, no. 3, p. 5, November 1915, 10 pp., 6 figs. *ep.*)

The Quincy Market Safety Valve for Ammonia Compressors, F. L. Fairbanks

While assisting the Massachusetts Board of Boiler Rules in its endeavor to find a reliable safety valve for ammonia compressors, the writer had occasion to perfect a valve previously in use at the plant of the Quincy Market Cold Storage and Warehouse Company in Boston, Mass. During the above referred to tests, six different makes of ammonia safety valves were investigated under various conditions and pressures. The general conclusions drawn from six tests were as follows:

a That valves with iron and steel seats were not safe for the reason that the disc is readily corroded to its seat by a small amount of moisture. Two of the six valves tested failed to open at 350 to 375 lb., although they were set at 250 lb. On being dissembled, these valves were found to be rusted solidly to the seat and to the winged guide in the port.

b That the cast iron valve discs with winged guides in the port, would not stand the excessive chattering and hammering on the seats, to which most of the valves may be subjected when opening and closing. One of the valves broke off its winged guide in the port and wedged the disc so that the line had to be shut off. Examination showed that the cast iron in both seat and guide was good and sound, the fracture being caused by the heavy chatter and pounds as it opened and returned to its seat.

c That the capacity of all the valves except the pop valve was very low.

d That the pop valve gave practically no warning when it was about to blow, and for this reason it would be dangerous to anyone who might be in the path of the discharge when it opened. Also, that the seat of the pop valve could not stand the blow of the valve when closed and remain tight.

e That none of the valves, notwithstanding their low capacity, could discharge through a pipe line no larger than their discharge outlet, and still maintain their setting and character.

The Quincy Market safety valve is shown in Fig. 8. It has no guide in the port, being guided by a bushing pressed into the valve port and by a cylindrical piston which has a port of what would be called the valve disc.

The face bushing is bored and reamed after being pressed in and the alignment of the valve depends upon this bushing, the seat being reamed through it as a guide, thereby making all parts of valve body and bonnet self centering and self aligning. The valve is cone pointed to present the least possible resistance to the flow of gas and is turned to an angle of 60 deg., the seat being reamed 1/32 in. wide and the angle being 57 deg., thus allowing the valve to seat on an edge and not on a flat surface. The piston guide is of sufficient excess area to secure the characteristics called for in the regulations and to cause the valve to open wide as the gas discharge increases and the back pressure builds up, the construction being such that the valve has the same features whether it is discharged through 500 ft. of pipe or directly from the valve outlet.

Like an old fashioned lever safety valve it opens at any predetermined point giving the operator sufficient warning to enable him to remedy the trouble in many cases. When this point is reached the valve continues to open as the pressure of the discharge side backs up on the increased area of the piston guide, the entire range being gradual and continuous until the back pressure reaches 0.585 of the initial pressure, thus giving in a valve practically the capacity and character of a Napier orifice. In tests the valve easily handled a displacement of 1700 cu. ft. per minute with 30 lb. to spare on the outlet side of the valve without chatter, shock or any other sign of distress. (*A.S.R.E. Journal*, vol. 2, no. 3, p. 45, November 1915, 5 pp., 2 figs. *d.*)

Thermodynamics

The Reversed Heat Engine as a Drying Machine, Paul J. Fox

The article represents an attempt at establishing principles and at designing an apparatus for air drying, based on the Kelvin principle of a multiple heat engine. This principle has been applied before in the design of a heating installation which would produce ice as a by-product.

In this case, the author states that the drying machine consists of three essential parts: *First*, a large metal expansion cylinder with a piston; *second*, a vessel in which the air

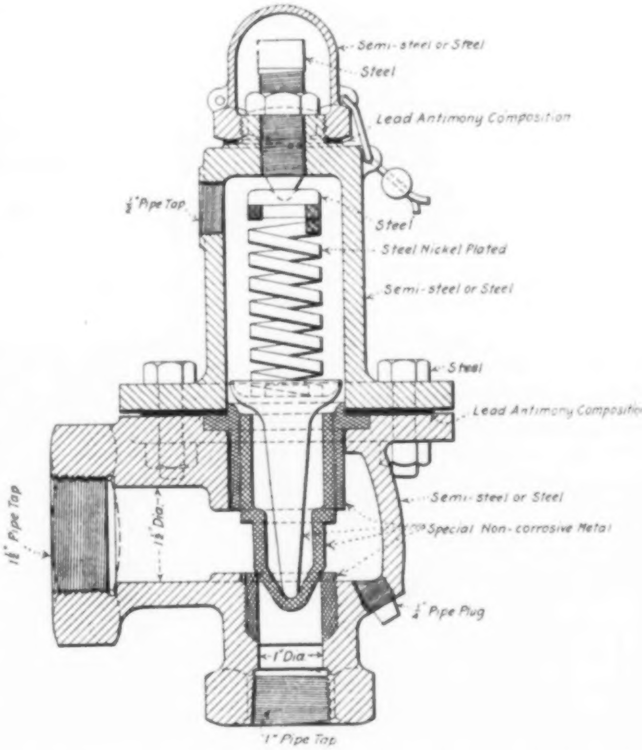

Fig. 8 Fairbanks Safety Valve for Ammonia Compressors

in the machine is allowed to come to atmospheric temperature and which may be called the atmospheric heater; and *third*, a large metal compression cylinder, also with a piston. The two pistons are connected to one piston rod. The cycle would be as follows: The gas would be allowed to come up to atmospheric temperature at the reduced pressure by retention in a suitable vessel, and finally compressed again to atmospheric pressure, the compression resulting in an increase of temperature. A single half stroke or single complete movement of the piston in one direction, completes a set of operations and delivers to the drying chamber the weight of the air taken in, which in the following is assumed to be 1 lb. in all cases. The atmospheric heater is merely a vessel for allowing the cooling and expanding air to come to atmospheric temperature. It may be a long tube or block or coil of tubes formed of thin metal to conduct heat to the enclosed air as rapidly as possible and to avoid mixing the warm and

cold gases. The tube would be of larger bore where the temperature difference between the atmosphere and the atmospheric heat was greatest. Because of the slowness with which the heat is communicated to a gas, the operation would be substantially adiabatic, although in the house warming engine, as proposed by Lord Kelvin, it is implied that the expansion of air *in the cylinder* should be isothermal; at least it is assumed adiabatic in the following: The atmospheric heater is then essential to bring the cold and expanded air up to the atmospheric temperature, and as the reduction of pressure amounts to only a few pounds, the walls of the heater would not have to be very heavy. In the heater the air expands from specific volume v_1 to v_2, and passes from temperature t_1 to t. The author makes the thermodynamic calculations for the engine as a drying engine, and finds formulae for all the magnitudes as well as for the constants. By applying the calculations to a concrete case, it takes the atmospheric temperature $t = 519$ absolute, or nearly 60 deg. fahr., and assumes that it is desired to dry at 100 deg. fahr., or 559 deg. absolute; then p of outside atmosphere and of drying chamber is equal to 14.7, v (specific volume of outside atmosphere in cu. ft. per lb.) = 13.085, t (temperature of outside atmosphere in deg. absolute fahr.) = 519, and t_3 (temperature of air on leaving compressor and in drying chamber in deg. absolute fahr.) = 559. The formula $p_1 = B\left(\frac{t}{v_2}\right)^{3.463}$ gives $p_1 = 11.40$, and $v_1 = \left(\frac{p}{p_1}\right)^{0.7113} v$ gives $v_1 = 15.68$. The characteristic equation $PV = RTm$ gives $v_3 = 14.093$, $v_2 = 16.87$ (on leaving atmospheric heater), and $t_1 = 482.2$ deg. fahr, absolute.

In discussing quantitatively the thermodynamic operation of the engine, the author summarizes the operations as follows: Each pair being a correlative process, he gives a plus or minus sign to each process, the plus sign being given when the process tends to turn the machine in the same direction as the power applied, and the minus sign when it opposes the power.

1 + is the taking of air from the atmosphere by the expansion cylinder.

1 — is the delivery of air by the compression cylinder to the drying chamber.

2 + is the expansion of the air in the expansion cylinder.

2 — is the compression of the air in the compression cylinder.

3 — is the discharge from the expansion cylinder to the atmospheric heater.

3 + is the discharge from the atmospheric heater to the compression cylinder.

The author discusses each pair of operations mathematically and derives the proper formula for their expression. All the calculations are of strictly thermodynamic character and do not consider the losses by friction or actual losses in engines. But it may be said that the common objections to air as a working substance do not apply here. Air has a low specific heat which causes the cylinders to be bulky but if drying is to be effected, the dry air must be pumped or introduced in one way or another into the drying chamber even if only by inefficient diffusion, and the machine suggested acts also as a pump. The difficulty of communicating heat to air unless the direct products of combustion are brought in contact with the substances to be dried, is a strong argument in favor of the engine, for in it the air is heated evenly and to the temperature desired. Again, the heat loss can be minimized. So far as the compression cylinder is concerned there is no reason why it should not be placed inside the drying chamber which would permit of utilizing the various heat losses by friction, etc., occasioned by heating the air for drying.

The most serious objection to the plan is found in the variation of temperature in the external atmosphere, since the machine heats the air through a fixed temperature difference for a given valve setting. This may be obviated either by adjusting the valves and varying the speed of the operation at different temperature ranges or by setting a number of machines in series with each machine lifting the air through a certain temperature difference and a varying number of them used as the atmospheric temperature changes. Finally the dry air would be heated higher than necessary and adjustment made from time to time by means of adding varying quantities of cool atmospheric air. (*The Journal of Industrial and Engineering Chemistry*, vol. 7, no. 12, p. 1065, December 1915, 5 pp., 1 fig., *td.*)

LOSS OF HEAT FROM STEAM-HEATED SURFACES

This paper was presented by Prof. Petavel, of the Manchester University, at a meeting of the Manchester Association of Engineers, October 30, 1915, and is based on the researches by the engineering staff of the Manchester University under the control of C. H. Lander.

The first part of the paper deals with problems of heat transmission and their particular bearing on heat losses sustained by steam heated surfaces. The second part deals with the efficiency of gas engines, the facts presented being based on experimental work carried out at the University of Manchester, by Prof. Asakawa, of Tokio, with the object of ascertaining by direct experiment, how near the efficiency of the commercial gas engine has approached the ideal. Finally is described a series of investigations undertaken to compare the strength of various structures as estimated by accepted methods of calculation with the actual strength determined by direct test. Within its purview is included a discussion of the strength of thick cylinders when subjected to internal pressures, and the complementary problem of the resistance of cylinders to collapse. The paper is quite voluminous and can be only briefly abstracted.

The author gives formulae for the radiation, conduction and convection in the flow of heat through a layer of gas separating two surfaces at different temperatures. The object of the research was to determine experimentally the heat flow under certain definite conditions and to estimate the relative importance of the above three modes of heat transmission. He describes the apparatus used for these tests and in several curves and tables gives a summary of the results obtained; viz., for experiments in air at atmospheric pressure; heat loss for steam pipes at various temperatures; change of loss with temperature (at habitual steam temperatures and at the entire temperature range, namely, from zero to 1500 deg. fahr.).

On the whole, the results point to the fact that the heat loss from steam heated surfaces is due mainly to convection. The loss by radiation in the case of a pipe of 1 in. external diameter is only about 15 per cent; the loss by conduction varies around 4 per cent, while convection accounts for about 81 per cent. The object attained by surrounding pipe with insulating material is to check convection currents and also reduce radiation. At the same time, all solid materials used as insulators are better conductors than air, so that the use of an insulating material really increases the loss due to conduction. Taking the case of a 1 in. pipe, a material such as slag wool or asbestos, if applied in a solid compressed block, would increase the total loss. The insulating effect obtained depends upon so arranging the substance that the least quan-

tity of material will sub-divide the space around the pipe into separate air cells as perfectly as possible. Thus the efficiency of slag wool is at maximum when the solid material occupies about one-fourteenth of the space. (Fig. 9 C.)

In a table are given values of heat lost from metal surfaces, such as bare steam pipes of various diameters under different temperature conditions, which did not, however, very materially differ from figures given by Fowler and Hiller. Another table given in the paper shows the saving of heat obtained by insulating coverings of various materials. It appears that magnesia filled rope and asbestos filled rope give the best results.

The paper proceeds then to the discussion of the effective pressure on the transmission of heat. The results of a number of experiments carried out in air at pressures up to 2500 lb. per sq. in. are given in Figs. 9A and B. It will be seen from Fig. A that as the pressure rises from atmospheric to 150 atmospheres, the loss per degree increases to nine times its original value, for a temperature of 152 deg. fahr. At high temperatures, say 2000 deg. fahr., radiation forms a large proportion of the total loss and hence the increase is relatively less. At all pressures the heat loss is very large for small diameters. It decreases rapidly as the diameter increases up to ½ in. and then becomes relatively constant for diameters above 3 in. It has further been found that conduction is important when the diameter of the hot body is small or the pressure of the air is low. Convection becomes the main factor when the air pressure is high or diameter large, and loss is principally due to radiation at very high temperatures and very low pressures. (*Proceedings, Manchester Association of Engineers*, through *The Mechanical Engineer*, vol. 36, no. 928, p. 357, November 5, 1915, 5 pp., 8 figs. *e.*)

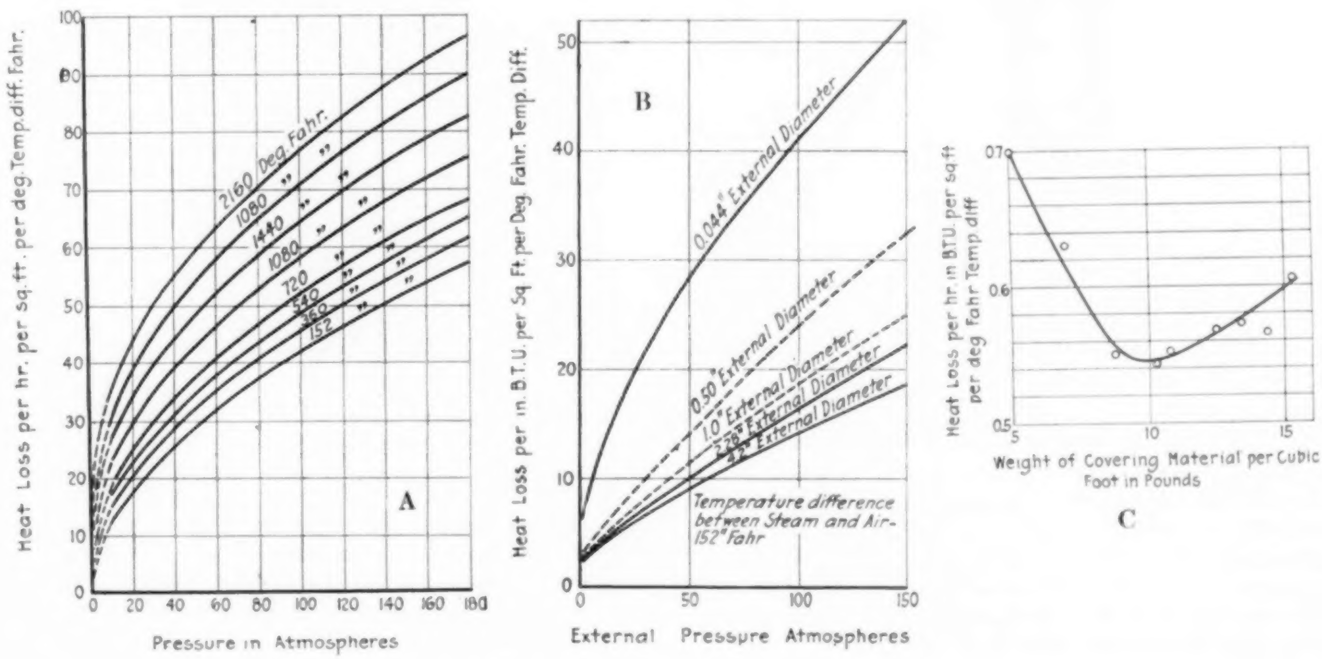

FIG. 9 LOSS OF HEAT FROM STEAM HEATED SURFACES

Miscellanea

SOME UNPUBLISHED LETTERS OF JAMES WATT
H. W. Dickinson

Small collection of letters representative of as many aspects as possible of Watt's activities. The letters are in chronological order and an attempt is made to indicate the purport of each and to explain the allusions in them. They are of considerable interest as an indication of the conditions under which engineers had to work in the latter part of the eighteenth century. Among other things, Watt discussed such matters as metallic piston packing, engine and pump troubles, duties performed by the atmospheric engine, boiler gages, iron cement, testing of materials, etc. Of especial interest is Watt's letter on the steam turbine, written in connection with the project introducing what was then known as Kempelen's engine. Watt pointed out that the engine was capable of improvements and in fact suggested some of them. He calculated the power developed by the turbine and found that with a velocity of 430 ft. per sec., the machine would develop 2½ h.p. and require a boiler evaporating 26 cu. ft. per hr., but with a velocity of 600 ft. per sec., the same engine might develop 11 h.p., and Watt summed up the situation as follows: "So that you see the whole success of the machine depends on the possibility of prodigious velocities. . . . In short without god makes it possible for things to move 1000 feet p^r" it can not do much harm, and by "much harm" Watt means of course, possible competition with his own machine. (*The Journal of the Institution of Mechanical Engineers*, No. 8, 1915, November 1915, 47 pp., *h*).

ARTIFICIAL ARM, Kesten

Description of an artificial arm developed lately, for the use of victims of war in Germany, at the works of Siemens-Schuckert Company, in Nurnberg.

It has hitherto been the practice when replacing a part or the whole of a lost arm, to attempt to reproduce the lost member artificially. This has some times been done with great mechanical ingenuity. In fewer cases an attempt has been made to replace the lost hand by means for holding special tools which would help the injured man, more or less, to carry on some kind of work. In this case, however, like in the preceding one, the attempt is usually made to attach the new apparatus to what remained of the lost member,

which materially reduces the amount of power which could be exerted through the substitute arm because of the reduced power of the arm trunk.

The Siemens-Schukert Company, acting at the suggestion of Dr. Silberstein, adopted an entirely new method, viz., to use what remained of the arm only as an auxiliary means of guiding the tool holder, which is however suspended from the *shoulder* and held by a strap, shown in Fig. 10, against the body of the man in such a manner that the strap passes under the other arm pit. The shoulder carries two ball-bearings *b* and *c*, of large diameter, and to the outer ring *c* are attached by joints, rods *e*, made of light steel tubing. (*d* shows the journals on which these rods are connected by a cup-shaped piece *f*, which takes up the double joint to which the tool proper is attached). The ball-bearings *b* and *c*, together with the movable joint in connection with the rods *e—e*, permit of moving the artificial arm in the shoulder joint just as one would a natural arm. The shoulder joint is perfectly free, and in order that the stump of the arm may be able to give the desired direction to the artificial arm, there is provided in the rods *e—e* and slide *g* which encloses the stump of the arm. The double joint which is carried on the cup-shaped piece *f*, is arranged in such a manner that it can permit of communicating to the tool attached to it both a circular and a joint motion, or practically a complete freedom of motion in any direction desired. (*Armersatz für Kriegsbeschädigte Handwerker und Arbeiter*, Kesten, *Zeits. des Vereines deutscher Ingenieure*, vol. 59, no. 43, p. 870, October 23, 1915, 3 pp., 5 figs, *d*).

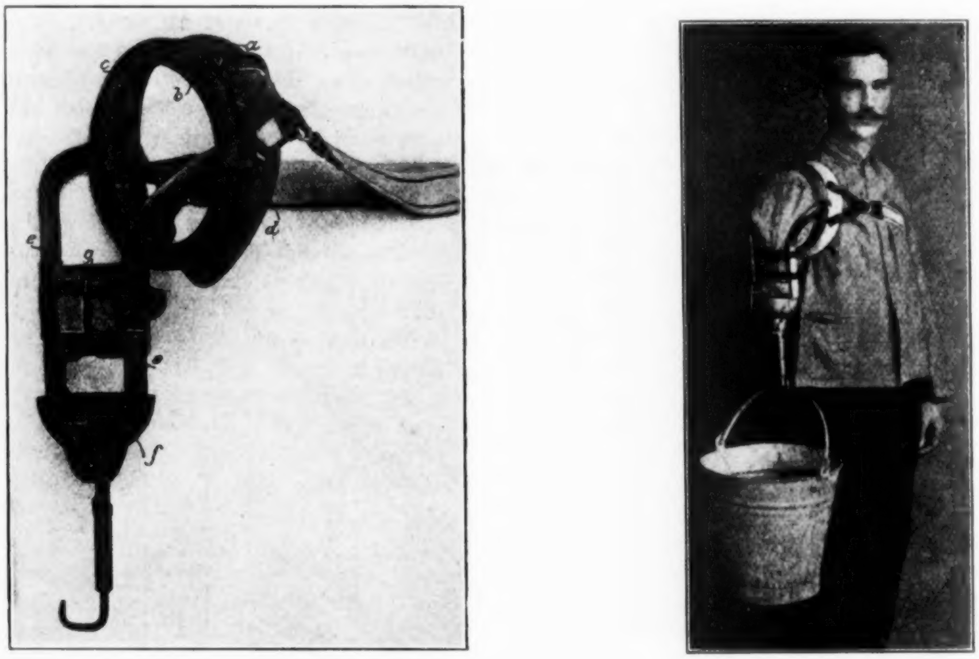

FIG. 10 SIEMENS-SCHUCKERT ARTIFICIAL ARM

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

CORRECTION

The article A Formula for the Comparison of Gasoline Automobile Performances (see abstract in *The Journal*, September 1915, p. 563), erroneously attributed to Theodore Douglas, is by *Cornelius T. Myers*.

SELECTED TITLES OF IMPORTANT ENGINEERING ARTICLES

AERONAUTICS

THE CAPTURED ALBATROS RECONNAISSANCE BIPLANE. Flight, no. 361, (no. 48, vol. 7), Nov. 26, 1915. 5½ pp., 11 figs.

MACHINE SHOP

MODERN METHODS OF TRAINING WORKMEN, H. L. Gantt. Efficiency Society Journal, vol. 4, no. 9, Dec. 1915, 6 pp.

MOTION STUDY FOR CRIPPLED SOLDIERS, Frank B. Gilbreth. Efficiency Society Journal, vol. 4, no. 9, Dec. 1915, 1 p.

ANTI-FRICTION METHODS IN SHOP MANAGEMENT, F. C. Blanchard. Efficiency Society Journal, vol. 4, no. 9, Dec. 1915, 6 pp.

SPEEDING UP METAL STAMPINGS PRODUCTION, Charles C. Lynde. Steel and Iron, 49th year, no. 31, Dec. 1915, 4 pp., 9 figs.

ELECTRIC WELDING MACHINE. Engineering, vol. 100, no. 2605, 1¼ pp., 3 figs.

RIVETING KINKS FOR STEEL CAR CONSTRUCTION, H. A. Hatfield. Steel and Iron, 49th year, no. 31, Dec. 1915, 2 pp.

GAS WELDING AND CUTTING, A SYMPOSIUM, C. K. Bryce. Proceedings of The Engineers' Society of Western Pennsylvania, vol. 31, no. 8, Nov. 1915, 11 pp., 7 figs.

ARTIFICIAL GAS FOR HIGH TEMPERATURE WORK, E. Raven Rosenbaum. Steel and Iron, 49th year, no. 31, Dec. 1915, 4¼ pp.

LA FABRICATION DES OBUS, Ch. Dantin. Le Génie Civil, Tome 67, no. 21, Nov. 20, 1915. 8¼ pp., 42 figs.
Outline of French methods of shell manufacture.

LARGE SHELLS: PRODUCTION PROBLEMS AND POSSIBILITIES, C. T. D. Canadian Machinery, vol. 14, no. 25, Dec. 16, 1915. 3 pp., 4 figs.

THE KINGSBURY THRUST BEARING, H. A. S. Howarth. Mechanical World, vol. 58, no. 1509, Dec. 3, 1915. 2 pp., 7 figs.

KEYWAYS IN SHAFTS, EFFECT UPON STRENGTH AND TWIST. Machinery, vol. 7, no. 166, Dec. 2, 1915. ½ p., 1 fig.

HOLDING DEVICES FOR TAPERED WORK, A. A. D. Machinery, vol. 7, no. 166, Dec. 2, 1915. 6½ pp., 11 figs.

FOUNDATIONS FOR JAR-RAMMING MACHINES, E. S. Carman. Iron Trade Review, vol. 57, no. 25, Dec. 16, 1915. 4 pp., 14 figs.

DEVELOPMENT OF QUICK ACTING FORGING PRESSES—1, A. J. Capron. Canadian Machinery, vol. 14, no. 25, Dec. 16, 1915. 3 pp., 2 figs.

LATHE FOR BORING 6-IN. SHELLS. The Engineer, *London*, vol. 120, no. 3124, Nov. 12, 1915. 1 p. Illustrated.

HEAT LOSSES IN STEAM TRANSMISSION, W. L. Cathcart. Cassier's Engineering Monthly, vol. 48, no. 6, Dec. 1915, 15 pp., 10 tables.

MARINE ENGINEERING

U. S. S. "CUSHING" DESCRIPTION AND TRIALS, Lieut. Ormond L. Cox, U.S.N. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915; 17 pp., 3 tables.

DESCRIPTION OF MAIN PROPELLING MACHINERY FOR THE U. S. S. "MAUMEE," Lieut. C. W. Nimitz, U.S.N. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 27 pp., 1 fig.

DESCRIPTION AND TRIALS OF U. S. S. TORPEDO-BOAT DESTROYER "O'BRIEN," Lieut. W. F. Cochrane, U.S.N. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 14 pp., 2 figs., 2 plates.

THE MYSTERY OF THE SCREW PROPELLER, Capt. C. W. Dyson, U. S. Navy. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 51 pp., 5 figs.

DESCRIPTION AND TRIALS OF U. S. S. "FULTON" (Sub-Marine Tender No. 1). Lieut. (J.G.) C. N. Hinkamp, U.S.N. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 1 p., 3 figs.

DESCRIPTION AND TRIALS OF U. S. S. "SACRAMENTO" (Gunboat No. 19), W. F. Sicard, Associate. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 30 pp., 1 fig.

DESCRIPTION AND TRIALS OF U. S. TORPEDO-BOAT DESTROYER "WINSLOW," Lieut. W. F. Cochrane, U.S.N. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 5 pp.

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